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2009

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Improving Right-of-Way Acquisition in Highway Projects through Scope Definition and Management of Inherent Factors

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Improving Right-of-Way Acquisition in Highway Projects through Scope Definition and Management of Inherent Factors

by

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

August 2009

To my son, Duy Le, with love, confidence, and hope.

(Tặng con trai Lê Duy của bố với tình yêu, niềm tin, và hy vọng.)

ACKNOWLEDGMENTS

My grateful thanks are due to my dissertation supervisors, Dr. Carlos H. Caldas and Dr. G. Edward Gibson, for their guidance, support, and confidence in me during the last four years of my Ph.D. study. Their profound insight into the subject matter has been an unwavering guiding light for me throughout the research process. Their high expectations have always been both challenging and motivating, and I am indebted to them. I would also like to thank my dissertation committee members, Dr. Cindy Menches, Dr. Arthur Sakamoto, and Dr. Michael Walton, for their enthusiastic support and valuable suggestions during the entire research process.

I am also thankful to the Texas Department of Transportation (TxDOT) for its financial support for both of the projects that constitute my dissertation. Furthermore, I highly appreciate the support and collaboration of the members of the Project Monitoring Committee of project 0-5478, the professionals of the Right-of-Way office of TxDOT's Austin district, and the professionals throughout Texas who participated in the data collection process for this study. In particular, I highly appreciate the enthusiasm and support of Mr. Tommy Jones of the Abilene district and Mr. Terron Evertson of the Austin district. Their enthusiastic participation was essential to the success of these projects. I would also like to thank Michael Thole, who was a graduate research assistant for project 0-5478, for his excellent collaborative efforts while conducting our research during the first project.

The Vietnam Education Foundation's fellowship made my Ph.D. study possible, and I am indebted to this support. I am thankful to the Foundation for its financial support during my first two years and its continuous support of my professional development throughout the last four years.

My Ph.D. study has been a long, challenging, yet enjoyable journey during which I have been fortunate to have met a wonderful circle of friends. While I cannot thank all them individually here, I want them all to know that I have the utmost gratitude for their friendship, both individually and collectively. I would love to thank two of them in particular. I thank Thuy Nguyen, a wonderful friend with a beautiful mind, for her friendship. Our numerous discussions, debates, and travels, just to name a few, can never be forgotten. My thanks are also extended to Tuyen Huynh for his availability to help anyone anytime, not only me but also other friends. He should be nicknamed "the people's friend."

My family has been an endless source of love and support. I am deeply grateful to my parents, my sister, and my brother for their unconditional love and confidence in me. I would also like to thank Khanh Van Dao for her attentive care of our son even under unforeseen and difficult circumstances. Her support has always been and will always be gratefully appreciated. Finally, my son, Duy Le, who was born during my first semester at UT, has been my greatest source of inspiration. He understands that daddy loves him more than anything but has to work and cannot play with him in Hanoi all the time. This dissertation is dedicated to him.

Improving Right-of-Way Acquisition in Highway Projects through Scope Definition and Management of Inherent Factors

Tiendung Le, Ph.D.

The University of Texas at Austin, 2009

Supervisors: Carlos H. Caldas and G. Edward Gibson, Jr.

Right-of-Way (R/W) acquisition is a critical function in the project development process (PDP). Improving this acquisition process requires both a good collaboration among the functions of the PDP and a good understanding of the factors affecting R/W acquisition. This research has two phases. Phase I aims at developing a systematic method for risk and scope management using scope elements that cover the work of all functions of the entire PDP. Phase II aims at studying the inherent factors that might have significant impact on the R/W acquisition schedule. As a result, the Advance Planning Risk Analysis (APRA) was successfully developed. It contains 59 scope elements with descriptions and a mechanism to assess the project's level of definition. The APRA can provide a platform for project participants to cooperate and coordinate project activities and responsibilities. The method provides a high level approach to improving the effective of the PDP and its functions, including R/W acquisition. In studying the R/W acquisition inherent factors in phase II, the research was able to draw conclusions on the impact of the identified inherent factors on R/W acquisition durations based on statistical analyses. The research was also successful in developing a statistically significant model for predicting the total R/W acquisition duration, from R/W Release to Possession, using inherent factors. This research provides a number of significant contributions toward the better understanding and improvement of the PDP process in general and the R/W

acquisition process in particular. Further research in this area and direction was recommended and believed to be promising, productive, and highly valuable.

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CHAPTER 1. INTRODUCTION

The project development process (PDP) is strategically important for highway projects. Its goals are to assure that the right project is selected and adequately planned for during the subsequent project phases. The PDP requires careful and detailed coordination among all participants involved in the project, who are involved in such tasks as planning and programming; design; environmental assessment; right-of-way acquisition; utility adjustments; plans, specifications, and estimates (PS&E) development; construction; and maintenance.

The project development process is a "long-lasting, comprehensive, and complex process" (Arts and Lamoen 2005). During these early project stages, the scope is defined and refined. Efforts invested during this period have far more influence on project success than those made during the construction phase (Gibson et al. 1995). Therefore, strategies and techniques that can streamline the project development process have the potential to improve overall project performance.

As an integral function of the PDP, the Right-of-Way (R/W[1]) acquisition process is usually on the critical path of a project's schedule. A study of R/W acquisition, therefore, needs to take into consideration the interrelation among R/W and other functions along with the investigation into R/W acquisition itself. This research aims at improving the effectiveness of R/W acquisition in the context of the entire PDP and in relation with other functions of the process. It first develops a scope and risk management method for the entire PDP, which includes R/W acquisition. It then analyzes the inherent factors of R/W projects and parcels to identify those that have significant impacts on the R/W acquisition schedule. It also aims at building a model for estimating R/W acquisition schedules using regression models.

This dissertation reports on the entire research process and its results. Chapter 1 sets the stage for the research with details on research motivation, objectives, hypotheses, and scope. Chapter 2 provides a review of literature relevant to the research topic. Chapter 3

[1] The acronym "R/W" will be used to designate right-of-way when used as a common noun. "ROW" will be used when referring to the Right-of-Way Division of a State Department of Transportation or when used as a proper noun/adjective.

reports on the research methodology. Chapters 4 and 5 describe the research process and results for two phases of the research. Chapter 6 discusses the relations between the R/W issues and scope definition. This chapter also offers recommendations for both practice and further research. Finally, Chapter 7 draws conclusions from the research findings and discusses contributions made by the research.

This dissertation draws from two projects performed for the Texas Department of Transportation (TxDOT). The first one was project 0-5478, entitled "Optimizing the Identification of Right-of-Way Requirements during the Project Development Process" that lasted from September 2005 to August 2007. The second project, entitled "Technical Assistance on Analyzing Right-of-Way Risks and Investigating Methods to Improve Right-of-Way Tracking," started in September 2007 and continues through August 2009. The author has been a graduate research assistant for both projects.

1.1. Research Motivation

The need to improve the project development process has been emphasized by recent studies that indicated poor cost and time performance of transportation infrastructure projects (e.g., Flyvbjerg et al. 2003). Reducing the time from the planning to construction of a project can ensure that the benefits of the project are available sooner to the traveling public. This will, in turn, more greatly facilitate public commerce, reduce adverse traffic problems and their associated costs, and enhance public confidence in the state transportation agencies (Gibson and Caldas 2005).

As a critical element of project development, R/W plays an important role in improving the efficiency of the process (NCHRP 2000). The R/W acquisition schedule is usually affected by schedule slippages arising in other functions such as preliminary design and environmental approvals. This interrelationship among functions and subsequent schedule overruns produce considerable uncertainty in forecasting the R/W schedule and overall project development schedule. For example, changes in horizontal and vertical alignments during design may necessitate changes in R/W requirements, sometimes to the extent that R/W mapping needs to be redone. R/W acquisition time is therefore likely to overrun. Moreover, facts discovered during the R/W acquisition process may trigger modifications or even rework in those functions.

Figure 1 illustrates the interactions between R/W with other functions in the PDP. The figure shows that R/W has two-way direct relationship with three out of four other main functions. It also has an indirect relationship with Planning and Programming function.

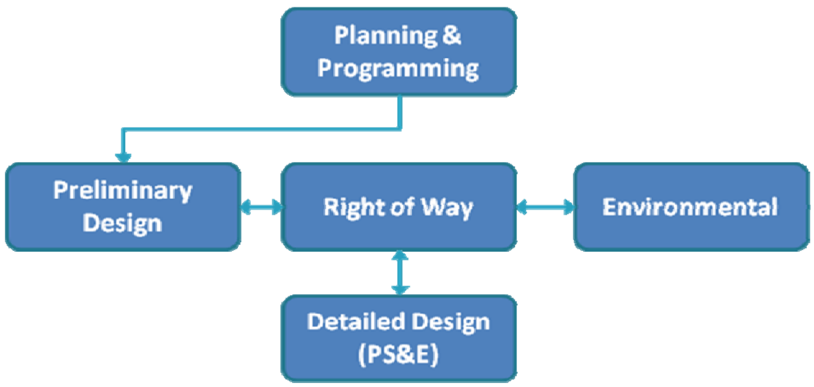


Figure 1. Relationship Between Right-of-Way and Other Main Functions in the PDP

These interactions between the R/W acquisition and other functions lead to two important points. First, there is a great interdependence among the functions of project development. However, it is reported that "many agencies have not yet achieved the full potential benefits of this integration" (NCHRP 2000). An approach that can allow for the coordination and cooperation among the PDP's functions would help improve each of the functions as well as the PDP as a whole. Second, in order to improve the effectiveness of the R/W acquisition process, it is critical to study inherent factors of a project and parcel that may have a significant impact on the schedule. The understanding of the significance of these inherent factors can help the project development team to better forecast the R/W acquisition schedule and devise an appropriate plan to cope with potential delays associated with a project's inherent factors.

Fostering the ability to improve the effectiveness of the R/W acquisition process through systematic management of scope elements and with a better understanding of inherent factors affecting a project's schedule is the major motivation for this research. Improving the PDP through systematic management of scope elements has been proven effective in building and industrial construction (Construction Industry Institute (CII) 2006a, 2006b). A review has revealed that the current literature does not provide a sufficient understanding of inherent factors affecting an R/W acquisition schedule. This research is divided into two major phases to address these two approaches to improving the effectiveness of R/W acquisition.

The first phase focuses on developing a method that can help identify, assess and monitor the requirements among the project development functions in a systematic manner. Such a method will be helpful to the project team in proactively addressing the problems that may arise due to a lack of adequate definition of the entire project development work. The method will lay a framework for coordination and cooperation in scope element management among PDP functions. Such a framework will allow for scope and risk management improvements in each of the functions as well as in the entire PDP as a whole.

In the second phase, the inherent factors affecting the R/W acquisition schedule are identified and analyzed. Those factors that have significant impact on the schedule will be determined through statistical analysis. The results will give the project team a better understanding of risky factors to the project development schedule over which the team does not have much control. The inherent factors will also be used to build a regression model of an R/W acquisition schedule. Improved understanding of inherent factors affecting each function, when combined with the coordination and cooperation in scope element management, would allow the project development team to manage risk more effectively by minimizing the occurrence probability of risks and devising better a plan to respond to risks when they occur.

1.2. Research Objectives

The main purpose of this research is to improve the right-of-way acquisition process through effective management of project development scope and analysis of project and parcel inherent factors. Specifically, this research has the following objectives:

- Objective 1: Identify and categorize critical project development scope elements;
- Objective 2: Determine the relative weights of the critical project development scope elements;
- Objective 3: Develop a systematic scope and risk management method to assess and monitor the project development scope definition using the critical scope elements;
- Objective 4: Identify and analyze the project and parcel inherent factors that have a significant impact on the R/W acquisition schedule; and
- Objective 5: Build a model for predicting the R/W acquisition schedule using the inherent factors.

1.3. Research Hypotheses

The two main hypotheses of this research are:

- Critical right-of-way related issues during the highway project development process can be identified, assessed and monitored systematically.
- Highway project and parcel inherent factors significantly affecting an R/W acquisition schedule can be both identified and statistically determined.

1.4. Research Scope

The first phase of this research takes into account functions in the project development process only, from need assessments to letting. During this phase, only highway projects of the following types are considered:

- Convert Non-Freeway to Freeway
- Widen Freeway
- Widen Non-Freeway
- New Location Freeway
- New Location Non-Freeway
- Interchange (New or Reconstruct)
- Bridge Widening or Rehabilitation
- Bridge Replacement

- Upgrade to Standards—Freeway
- Upgrade to Standards—Non-Freeway

The second phase of the research studies only inherent factors that may affect the R/W acquisition schedule. Factors affecting R/W acquisition cost will not be considered. The inherent factors are defined as factors of the project and parcel that are relatively independent of the project team's direct influence and control. The data collected for this research are mainly from the state of Texas.

CHAPTER 2. LITERATURE REVIEW

This chapter reviews the literature that relates to this research. It starts with an overview of the project life cycle and the project development process. This review continues with major studies related to the R/W acquisition process and schedule. Then, studies pertaining to scope definition and management in project development in different construction industry sectors, including highway, are reviewed. The chapter concludes with a summary of the literature review and a highlight of the gaps in the literature and subsequent need for this research.

2.1. Project Life Cycle and Project Development Process

A highway project's life cycle has six main phases, as shown in Figure 2. These phases are relatively sequential, but much of the work can be overlapping and includes needs assessment, feasibility/scoping, preliminary design, detailed design phase, construction, and operation and maintenance. A project starts with an assessment of needs, which could be initiated by virtually anyone, including area office staff, district staff, maintenance supervisors, local officials, developers or the traveling public (TxDOT 2003). The next phase is the feasibility study and scoping in which issues related to purpose, need, alternatives, and scope are analyzed and determined. Preliminary design is the next step that involves collecting data and developing schematics. In detailed design, most details about the project elements are developed to ready the project for the construction phase. Along with these two phases, a transportation infrastructure project usually has environmental and R/W and utilities processes. The construction phase involves the actual physical construction of project structures and facilities. After construction, the project moves to the operation and maintenance phase, which marks the end of the project; the new facility becomes an asset that must be managed.

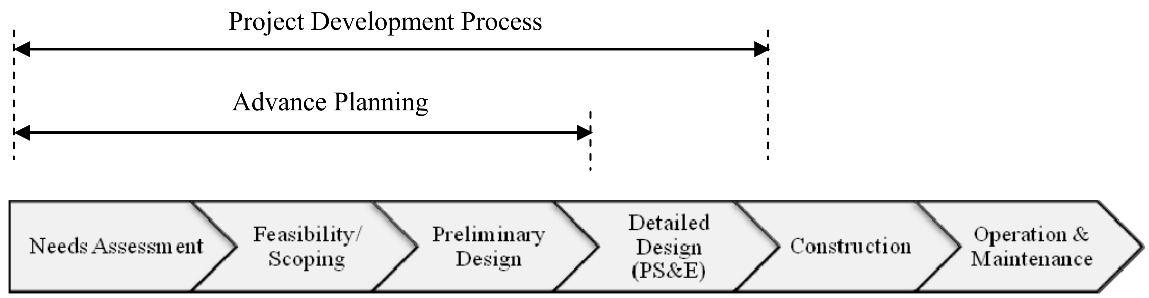


Figure 2. Project Development and Advance Planning Processes in the Project Life Cycle

The project development process is the period that covers all of the first four phases of the project life cycle, from needs assessment to detailed design (Figure 2). A term that is closely related to the project development process is "advance planning." This term refers to the process that includes the first three phases (needs assessment, feasibility/scoping, and preliminary design). Both of the terms, the project development process and advance planning are used widely in state and federal highway agencies (such as State Department of Transportation and Federal Highway Administration). Advance planning may be referred to with several terms; the most frequently used ones are pre-project planning, front-end planning, and conceptual planning. Such planning is defined by the Construction Industry Institute (CII) (1994) as "the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project." This is an important subset of project planning, and it is typically the responsibility of the owner (Gibson et al. 1995). The early intensive involvement of major project stakeholders with diverse expertise (for example, planning, design, environmental, right-of-way, and construction) is required if the project's objectives are to be met effectively.

2.2. Right-of-Way Acquisition for Highway Projects

In an effort to help improve the project development process, the Center for Transportation Research (CTR) at the University of Texas at Austin has performed a research project on durations and delays in highway project R/W acquisition and utility adjustments. The results of this research include the successful development of a comprehensive work process model and duration metrics for both R/W acquisition and utility adjustments. The research results would help the project development team to focus on highly important issues, especially in the domains of R/W acquisition and utility adjustments that have the most impact on the durations of a project. Nine categories of delay factors were identified by the research (Gibson et at. 2006):

- "Pricing Compensation and Impact on Remainder Delays;
- Title Curative and Ownership Delays;
- Third Party Delays;
- Parcel Characteristic/Improvement Delays;
- Legal Activity and Litigation Delays;
- Utility Delays;
- Environmental Sensitivity and Expert Witness Delays;
- Design Change and Revision Delays; and
- Resource and Manpower Delays."

In each of these categories, there are a number of specific challenges that may cause delay. These challenges are accompanied with "potential management strategies." In studying the R/W acquisition schedule, the research used three durations. R1 is the duration from R/W Project Release to Possession; R2 is the duration from First Parcel Appraisal to Possession; and R3 is the duration from R/W Project Release to First Parcel Appraisal. By analyzing the relations among the factors that drive R/W acquisition and the durations, this research concludes that there are four major factors affecting R/W acquisition duration; they are "Total number of parcels," "Location type," "District R/W staff size," and "District annual R/W budget" (Gibson et at. 2006).

In other research, CTR has recommended best practices in R/W valuations and negotiations for TxDOT to reduce the time and cost of the R/W acquisition process. The recommendations include the following (Caldas et at. 2007):

- "Regularly train, monitor, and evaluate the expertise of R/W staff, fee appraisers, and review appraisers;

- Involve and contact the property owner personally early in the acquisition process;
- Streamline the valuation process to maximize production time, cost, and efficiency benefits;
- Simplify value determinations, reporting protocols, and review procedures;
- Inform property owners of what will take place at each step about the entire acquisition process;
- Promote frequent communications with property owners for better coordination and to minimize time;
- Use simplified and efficient negotiation processes in order to reduce time/cost and enhance quality of negotiation process;
- Encourage agents to perform negotiations in a manner that inspires owner confidence;
- Minimize the possibility of proceeding to condemnation; and
- Emphasize the significance of providing property owners with all the information required by law."

In line with research on improving the ROW and Utilities functions of the project development process, the American Association of State and Highway Transportation Officials (AASHTO) in 2004 published "Right of Way and Utilities Guidelines and Best Practices." It provides guidelines and best practices for major functional areas in the R/W and utilities process (AASHTO 2004). The document addresses eight areas in this process, including project development, appraisal and appraisal review, acquisition, relocation, property management, utilities, management practices, and training. There are a total of 43 guidelines in these eight areas. Each guideline is associated with a number of best practices that can help when entities attempt to implement the guideline. This document is an excellent resource for improving the R/W and utilities process because it disseminates what is known about the best practices so that these can be put into actual practice.

The Federal Highway Administration (FHWA) has also performed a scanning study that gathers the best practices in R/W and utilities in selected European countries that can be applied to the U.S., and it published a report called "European Right-of-Way and Utilities Best Practices" (FHWA 2002). This report divides the process into the following five areas: appraisal and acquisition, compensation and relocation assistance, training, utilities relocation and accommodation, and project development. For each area, the report discusses primary findings and observations obtained through the visits to European countries. After having discussed the findings and observations, the report provides recommendations and implementation activities for each of the areas. The document is unique in its investigation of the R/W and utilities process in the European countries.

The National Cooperative Highway Research Program (NCHRP) also published "Innovative Practices to Reduce Delivery Time for Right-of-Way in Project Development" (NCHRP 2000). In this document, instead of dividing the process into different areas, the report discusses the state of practices pertaining to R/W. It emphasizes the importance of positioning and tasking R/W in close relation with other functions such as planning, environment, design, and law. The report then discusses the influence that laws, regulations, and policy have on R/W delivery. And finally, the document provides an overview and discussion of innovative project management models in several states. Among valuable findings from this study, there is a list of factors that are considered to contribute highly to success in expediting delivery of R/W. These factors are the following (NCHRP 2000):

- "Include R/W in setting and revising project schedules;
- Perform R/W activity as much as possible in parallel with other functions, rather than waiting for a "hand-off" from an upstream function;
- Delegate authority for project decisions to project personnel, rather than retaining authority at a more remote level;
- Encourage a collaborative atmosphere, where actions that affect more than one discipline would receive full consideration from all affected parties;

- Train in new project development roles and relationships that extend beyond their traditional core job competencies."

In addition to these publications, State Departments of Transportation maintain systems of procedures, maps, and manuals on the project development process and its functions. These publications serve as a foundation for the investigation to develop products during the first phase of this research. Chapter 4 will discuss further how these sources of information, among others, are utilized during the whole research process.

In a study of 55 projects, the Center of Transportation Research at the University of Texas at Austin (Gibson et al. 2006) analyzed the differences in R/W acquisition durations among groups of parcels, including the following: random versus critical path parcels, parcels in 10-to-30-parcel projects versus greater-than-30-parcel projects, urban versus rural projects, differences in district budget levels, and differences in the number of full-time equivalent employees. The durations researched were those periods between pairs of milestones among "R/W Release," "Appraisal," and "Possession." This research provides a good understanding of a number of factors that affect R/W acquisition. However, it focuses more on the project level than on the parcel level acquisition time because in most of the analyses, durations of critical parcels were used. Moreover, the research analyzes a number of general factors, not specific factors inherent to particular projects. A similar study that would investigate the impacts of inherent factors at both the project and parcel levels would offer more helpful findings.

2.3. Scope Definition and Management in Project Development

Arguing for the necessity of a quantitative method for rating the state of project definition, Hackney proposed one that uses checklists (Hackney 1965, 1992). In developing this method, Hackney focused on improving the accuracy of the estimation for process-type facility projects such as chemical plants. This checklist can also be considered a tool for defining project scope. It includes 27 items that are organized in the following six categories: 1) general project basis, 2) process design status, 3) site information, 4) engineering design status, 5) detailed design, and 6) field performance. Although much of this method is designed for estimating projects in their early phases, its intended use also includes detailed design. Each of the 27 items was assigned a weight based on the experience of the author on the relative importance of that item to the project. A category's score, then, is the sum of the scores of all items in that category. The scores of all categories thus add up to become the project's score. The project score represents how much is known, or unknown, about the project.

This checklist was later revised in 1992 to include 29 items, still organized into 6 categories using a similar approach (Hackney, 1992). Apart from this checklist, Hackney also proposed a checklist specifically for hazardous waste projects. Hackney's method based on these checklists is complicated in calculations while taking into account the experience of a group of experts in determining the items' weight. The methods are sophisticated and, therefore, difficult to use. They are more appropriate for use with projects of closely related types and in an environment similar to that of the author. They also require a good understanding of the methods in order to be effectively put to use.

The Project Definition Rating Index (PDRI) is a successful advance planning risk management method developed by the CII (2008a, 2008b) for assessing project scope definition during front-end planning of building and industrial projects. Front-end planning in building and industrial construction is similar to advance planning in transportation. The PDRI has a list of project scope elements, including descriptions, which are organized into categories and sections. Using a rating mechanism for each element's definition, the PDRI allows the project team to determine the level at which a project is defined at any given time during the front end planning process. It presents this level using an index.

Using the PDRI as a tool for evaluating the level of definition of a project, the CII studied a sample of 129 industrial projects worth \$6.7 billion and of 108 building projects worth \$2.3 billion to investigate the relationship between front-end planning efforts and project success. The study found that project performance differences between the sample of well-defined projects and the not-so-well-defined projects amounted to an approximately eight percent difference in cost savings, a six percent reduction in schedule, and a minimal difference in change order value for industrial projects. For building projects, these differences amounted to six percent in cost savings, 16 percent in schedule reduction, and a three percent decrease in change order value (CII 2007, 2008a, 2008b).

A research project by Shane (2006) aimed at developing a scope definition index to be used in early project planning on highway projects that are executed using the design-build project delivery method. Shane developed a list of 45 attributes through a content analysis of current project definition rating indices including the PDRI, state highway agency documents, and other sources related to attributes that may influence highway project outcome. An evaluation model was developed by interviewing industry leaders from state highway agencies and design and construction firms. The results of the model include importance levels of the identified attributes. This model was meant to evaluate the scope definition of a highway project. Finally, a database was developed using case histories to help determine the scope that is necessary to achieve a higher likelihood of project success. In this research, Shane focused on design-build projects, which are normally let with less than 30 percent of design completed. This level of design is usually obtained at the completion of preliminary design. This research, while making an important contribution to scope definition in the early phase of project development, does not address scope definition from the end of preliminary design to the completion of detailed design, an important period that involves a high level of both activity and complexity in all major functions such as environmental process, right-of-way acquisition, utility relocation, and design.

2.4. Literature Summary

The review of the related literature has shown that project development is a critical process in determining the effectiveness of a project. The review also revealed a good number of studies related to scope definition and management in project development. These studies provide excellent references and, at the same time, highlight the need for a scope definition and management method for highway projects during the entire project development process. The method should be able to address all critical scope issues during the PDP of all major functions, including R/W. The review on R/W acquisition process and schedule underscored the importance of the R/W acquisition in project development. The gap, and therefore the need, also arose regarding the study of the impact of inherent factors on an R/W acquisition schedule. Altogether, the literature review provided a good foundation and references for this research, but at the same time, it highlighted the existing knowledge gap and thus the need for this research. The next chapter will present the research methodology for both phases of this study.

CHAPTER 3. RESEARCH METHODOLOGY

Chapter 3 presents in detail the selection of research methodology and specific research methods for each phase of the study. In the first section, the rationale for the selected research methodology approach and research methods will be discussed. The next section shows in more detail research steps in the first phase of the study. Research methods and steps for the second phase will be elaborated upon in the third section, followed by a section on how conclusions and recommendations from the research will be drawn and made.

3.1. Research Design

An overview of the research methodology is illustrated in the research process flowchart in Figure 3. The researcher used a research methodology approach that mixes qualitative and quantitative methods. Such an approach allows the researcher to utilize the advantages of different research methods, be they qualitative or quantitative, to attain the desired results sought in different aspects of the research (Creswell 2008). As can be seen in the research process flowchart, after research design is completed, the research has two phases, which are developing a scope definition and management method and analyzing the inherent factors of the R/W acquisition schedule.

In the first phase, qualitative methods are used to identify and categorize the scope elements. The elements are weighted using a quantitative method. And in the testing process of the method and tool that would be developed, both qualitative and quantitative methods are used. The second phase uses mostly quantitative methods to analyze the impacts of the inherent factors on and build a prediction model for the R/W acquisition schedule. However, some qualitative methods, such as in-person interviews, are also used in support of the quantitative methods early in this phase. Methods used in the two research phases will be reported in the next two sections.

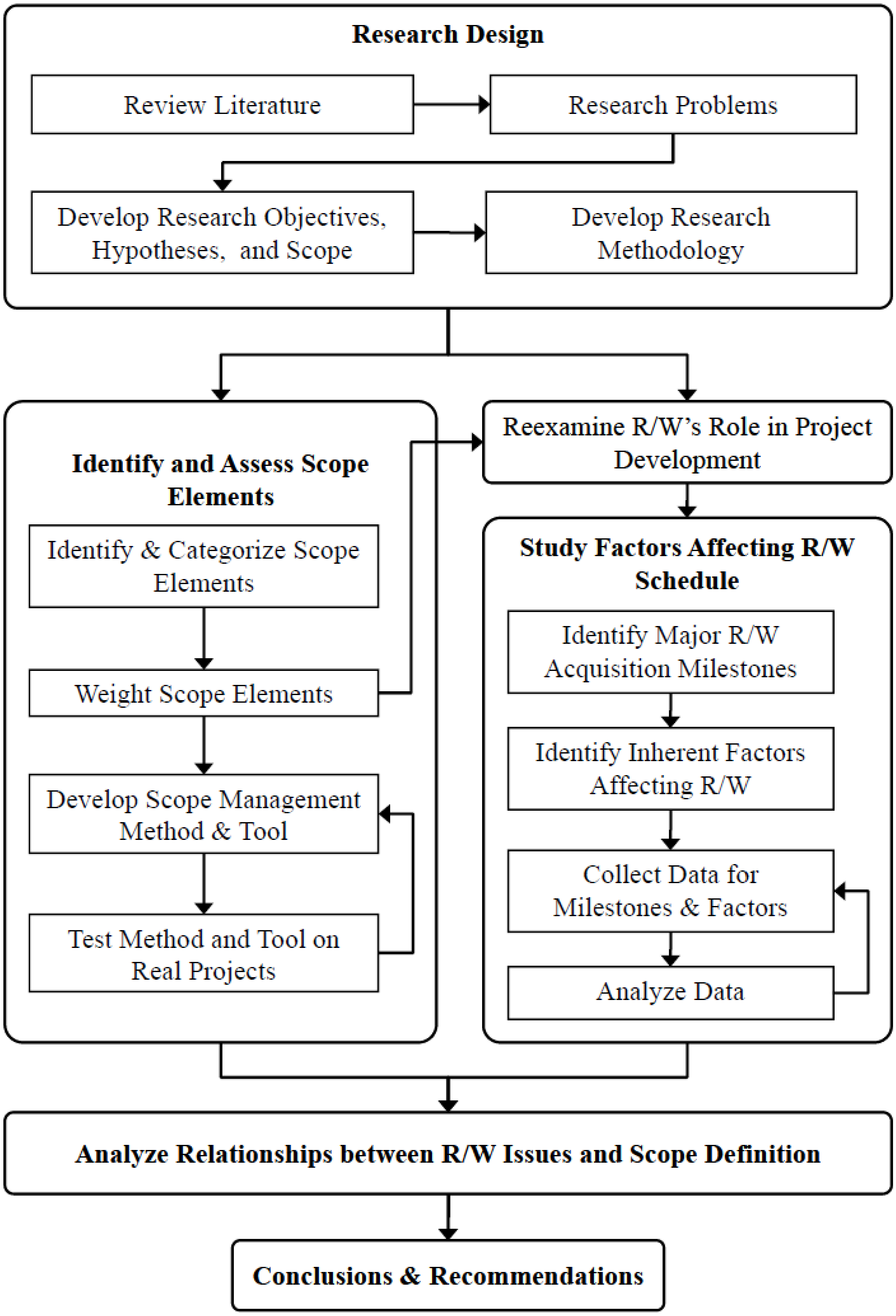


Figure 3. Overall Research Process Flowchart

3.2. Phase I – Identifying and Assessing Project Scope Elements

There are four main steps in this phase of the study. The first step is to identify and categorize scope elements of all major functions during the PDP. The next step is to weight these elements according to their relative impact on the project outcome. In the third step, a method and a tool for scope definition and management are developed. As the final step, the method and tool are tested on real projects to evaluate their usefulness.

3.2.1. Identification and Categorization of Scope Elements

The research uses several methods in identifying scope elements to take advantage of different sources and to ensure a generic coverage of issues in project development. First, relevant literature is reviewed with special emphasis on the documents describing and defining project development at both state and federal levels. Second, the research uses interviews with subject matter experts as a method to obtain insights into current practices, processes, tools, methods, and problems in the project development process. Third, meetings with the research sponsor (of project 0-5478), represented by the Texas Department of Transportation Project Monitoring Committee, are used as a method to gain input from another group of subject matter experts who are in charge of the project from the sponsor standpoint. Fourth, a series of internal research meetings utilizes the team expertise and experience in identifying and especially categorizing the elements. The elements are categorized according to the following objectives:

- Key planning elements should be categorized in a manner that followed the chronology of phasing in the project development process.
- Categories should promote interaction among divisions and/or disciplines, as opposed to assigning groups of elements to one division or another.
- Categories should promote interaction among project stakeholders, including consultants and contractors.
- Key planning elements should be grouped according to some thematic relationship—not based on functional areas, but on project phase objectives.

3.2.2. Scope Elements Weighting

The next step in this first part of the research is to weight the identified scope elements. The relative levels of impact of the various elements are not obvious. These impact levels should reflect the practices of project development, thus expertise from experienced participants in project development should be utilized to weight the elements. Among the several considered methods for weighting the elements, the research team determined that using workshops to tap the expertise of experienced professionals was the most suitable way to evaluate the elements' relative importance. Workshops have the advantage of offering direct interaction with the participants, while at the same time avoiding too much attention to the study itself, as such attention could influence participants' response. Multi-participant workshops also allow maximizing the homogeneity of the information conveyed to the participants, a homogeneity that can hardly be obtained using other methods such as interviews or mail surveys. Workshops are also a great method in improving the response rate as compared to surveys. This method has also been proven successful and effective for this type of work in a number of previous research efforts at the Construction Industry Institute (2006a, 2006b). In determining the weight of each element, both cost and time impact are considered and presented in the form of a unified cost factor. Completed projects are used by workshop participants as the reference point to determine the elements' relative importance. The weighting process is therefore retrospective in nature.

3.2.3. Development of Scope Management Method and Tool

The results from the identification, categorization and weighting of the elements in the previous two steps are used as the basis to develop the scope definition and management method and tool. The method describes how the elements and their weights are used to evaluate the scope definition of project development, and how to use them both in the context of a project and an organization. During this method development process, input from the Project Monitoring Committees is sought to make sure the method is practical and useful to users. An important part of the method is a computer tool, which is expected to enhance its usability and efficiency. The tool was thus developed using the Microsoft Excel®, a common software application, to improve user-friendliness and to reduce potential implementation costs for users.

3.2.4. Testing of Scope Management Method on Real Projects

A great deal of input from experts and the research team members is incorporated into the development of the draft method and the computer tool. It is still necessary to test the method and its computer tool on real projects with the people who are its potential end users. Such testing would allow for generating the potential benefits of the method, collecting more comments and critiques on the method and the tool to revise and improve them, and familiarizing potential future users with the method.

Both completed and ongoing projects have been selected for testing the method. The main output of the testing process is the compilation of observations of how the method is used in a real environment, what kinds of potential benefits it might bring to the team, and participants' comments and assessments on the method and its tool. The testing process also allows for preliminary analysis of the level of project development scope definition in practice using the method. The output from the testing process is used to refine and finalize the method and tool.

3.3. Phase II – Identifying and Analyzing Factors Affecting Right-of-Way Schedule

Prior to the official start of the second phase, the R/W's role in project development is reexamined using the output from the first phase. R/W's relative importance in project development is determined based on the weights of the R/W related scope elements. The second phase starts with the identification of major R/W acquisition milestones, which is followed by the identification of the inherent factors affecting R/W schedule. Next, data for the milestones and factors are collected and checked. The collected and checked data are then used to develop a regression model for the R/W acquisition schedule and analyze the impacts of the factors on R/W acquisition durations.

3.3.1. Identification of Major Right-of-Way Acquisition Milestones

The comprehensive "Right of Way Acquisition Process Flowchart" developed by the TxDOT is adapted to identify the major milestones in the R/W acquisition process. A group of R/W experts is consulted in selecting the major milestones. These milestones are used to calculate durations between the milestones. These durations are used in later analyses of what factors play a significant role in affecting the R/W acquisition schedule.

3.3.2. Identification of Inherent Factors Affecting Right-of-Way Schedule

Inherent factors are defined as those factors of the project and parcel that are relatively independent of the project team's direct influence and control. Two main methods are used to identify these inherent factors. First, any relevant literature is reviewed to obtain the inherent factors that have been identified in previous studies. Second, subject matter experts are interviewed by the research team to identify those factors that, based on the experts' experience, could affect the R/W schedule and how they could possibly affect it. These two methods allow for a thorough identification of the inherent factors. The list of factors is further refined during the data collection phase when more expert input is available and the availability of data is better known.

3.3.3. Data Collection and Checking

Projects that have been under the management of the TxDOT's Austin district and started no more than five years from the data collection start date are selected for this study. The time horizon requirement of the projects was chosen to maximize data reliability and comparability. Those projects whose data are not within the accessibility of the Austin district are excluded from this research because data on these projects are unreasonably difficult to collect. An example of such projects is the projects that were outsourced to consulting companies whose consulting contracts have since expired.

After the projects have been identified, data for the parcels' milestones and inherent factors identified from the first two steps are collected. The main sources of data include the following:

- TxDOT's Right of Way Information System (ROWIS): a system maintained by TxDOT to record various types of data on R/W acquisition.
- Tracker: an internal tracking system used by the Austin district's R/W group to record time and cost data of the R/W acquisition process.

- Physical files of the projects: the physical files used to keep track of the R/W acquisition documents related to the projects and their parcels.
- Interviews: a method mainly used to obtain the data about the factors affecting the R/W acquisition schedule.

Once the preliminary data collection is completed, durations between milestones are calculated. These durations are used first to identify the possibly inaccurate dates of the milestones. This is an important step to maximize the reliability of the data collected because a high volume of data are collected (there are many parcels, each of which will have a number of milestones) and much of the data recording process is done manually. Any dates whose accuracy is in doubt are highlighted and checked manually.

3.3.4. Regression Modeling of Right-of-Way Acquisition Total Duration

A regression model for the R/W acquisition total duration is built based on the inherent factors identified. First, stepwise regression is used to screen insignificant factors from the simple linear regression model. Transformations of factors are then considered and compared to the simple linear model. Next, with the remaining significant factors, interaction and second-order terms are added to the model. Stepwise regression is used again to select only the significant terms. Multicollinearity among the terms is examined using the Variance Inflation Factor (VIF). Finally, the model is validated against the regression assumptions before being finalized.

3.3.5. Analysis of Factors Affecting Right-of-Way Schedule

Incorporating data collected for the inherent factors and numerous R/W milestones, analysis of variance (ANOVA) is used to analyze the impact that the factors may have on various durations between pairs of R/W milestones. The relationships between quantitative factors and the durations are investigated using correlation, and the relationships among the R/W durations are also analyzed using this technique. Results from the ANOVA and correlations serve as the basis for conclusions about the impact of the factors on the durations as well as the relationships among the factors and among the durations.

3.4. Analyzing the Relations Between the Right-of-Way Issues and Scope Definition

The findings from the two phases of the study are used to make sense of the relations between the R/W issues and scope definition. First, the R/W issues identified and analyzed in during the first phase of the study are examined in relation to the project development process as a whole. Second, how the method and tool developed in the first phase can be used to address the R/W inherent factors is discussed. Third, the role of the inherent factors in determining the R/W acquisition schedule is discussed along with how other types of factors could potentially affect such schedule. Finally recommendations are offered for both practice and further research.

3.5. Conclusions

Once both research phases have been completed, research objectives and hypotheses are revisited to determine how the research results address the initial objectives and hypotheses. Limitations of the research and its delimitation are discussed based on the actual proceedings of the research. Contributions made by the research to the body of knowledge are summarized. Finally, conclusions on the research are drawn and presented in the final chapter.

CHAPTER 4. PHASE I - IDENTIFYING AND ASSESSING PROJECT SCOPE ELEMENTS

This chapter reports on the first phase of the research. In this phase, the project scope elements were identified and assessed based on their relative importance to the project. These elements and their weights were then used to develop a method and tool for assessing and managing scope during project development. These were both tested on real projects and proved to be helpful to practitioners. The method was named Advance Planning Risk Analysis (APRA). Figure 4 illustrates the research process in this phase. Each of the steps will be presented in detail in the following sections.

4.1. Identification and Categorization of Scope Elements

This research step was performed in close collaboration with Mike Thole who was a Graduate Research Assistant in project 0-5478 from September 2005 to December 2006. The collaborative work was published in a report for the research sponsor, the Texas Department of Transportation. This report (Caldas et al., 2007) provides a high level of detail on the identification and categorization of the scope elements. In this section, the process and results of this research step will be briefly presented.

The identification and categorization of scope elements included three steps as shown in Figure 4. The first two steps were conducted in tandem to generate an initial list of the critical risk elements that need to be addressed during the transportation project development process. In the first of these parallel steps, the Documentation of Related Processes and Sources, the research team investigated a variety of literature sources relevant to the research topic, including the following:

- The Texas Department of Transportation (TxDOT) online manual system, process maps and project development models, and Right-of-Way Considerations training course and materials (CII 2004, 2007; Shane 2006; Chang 2005; Caldas et al. 2007; AASHTO 2004; FHWA 2002; and NCHRP 2000);
- Procedural manuals from select state departments of transportation such as those of the Minnesota Department of Transportation (2002);

- Sources from other agencies and institutions, including the Federal Highway Administration (FWHA 2000, 2001, 2002), Transportation Research Board (NCHRP 2000), and CII (2006a, 2006b); and
- Input from periodic meetings with TxDOT's Project Monitoring Committee (PMC), which comprises experienced experts and senior management personnel.

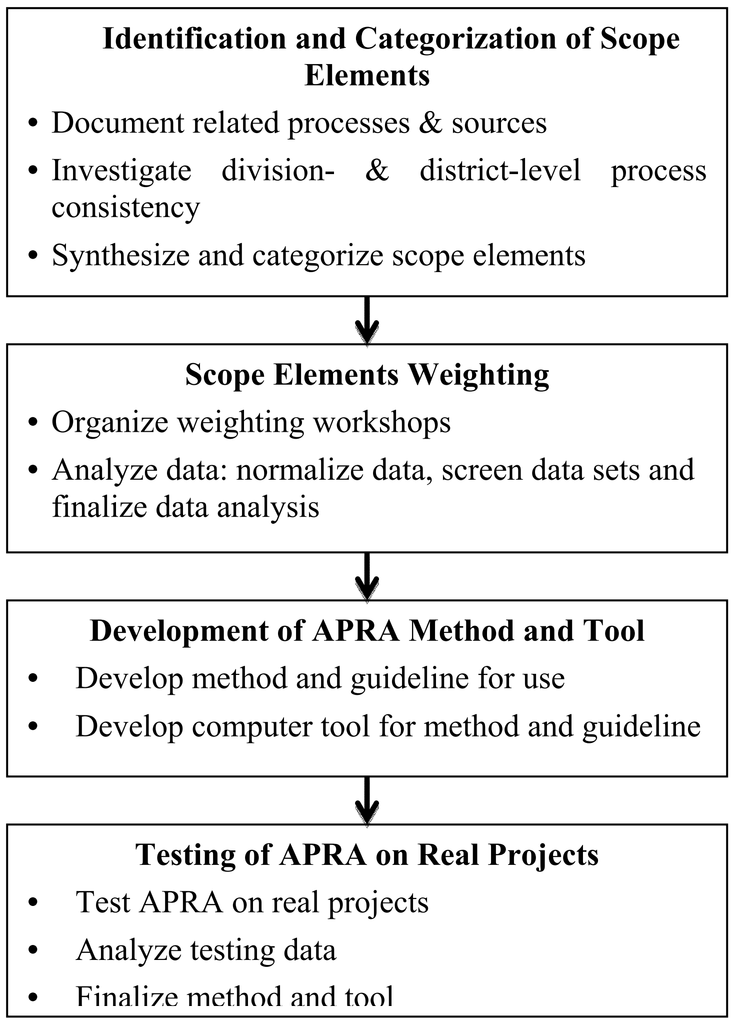


Figure 4. Detailed Research Flowchart Phase I: Identifying and Assessing Project Scope Elements

In generating a preliminary list of scope definition elements, the research team also investigated the process consistency at both division- and district levels in Texas. It was assumed that investigating process consistency could allow the researchers to find the critical advance planning elements from the inconsistencies that would emerge. The team chose to use face-to-face interviews with professionals with relevant experience to obtain this type of data. The team conducted interviews with a total of 11 experienced professionals working in various district and division offices in TxDOT. An excerpt of the interview guide is included in Appendix 1.

As a result, a preliminary list of 59 scope definition elements was generated with descriptions that provide essential information about each of the elements, their significance to the project, and the considerations they require. These elements are applicable to the different functions of project development (e.g. design, right-of-way, utilities, project management strategies, contractual agreements, and environmental) and relate to different phases of the project life cycle (e.g. advance planning, design, and execution). The tasks described by these elements involve all stakeholders of the project, including federal and state agencies. Given the dimensions of the list, the synthesis and categorization of the elements have a number of requirements that may be conflicting in nature.

The research team, therefore, chose the most important criteria to meet. They are: 1) the elements would be categorized in a manner that represents the relative sequences of phases in the project development process, and; 2) the categories would promote the interaction among the project development team members within the owner's organization and between the project development team and the external stakeholders. After a series of internal research team meetings the 59 elements were categorized into 12 categories, which were further grouped into three sections. In this categorization process, the PMC was closely involved so that it could provide feedback regarding contents, descriptions, phrasing, and the organization of the elements in discussions at meetings and during individual reviews. The scope definition elements and their categories and sections are presented in Figure 5 (sections I and II) and Figure 6 (section III). An example of one of fifty-nine elements' descriptions, Determination of Utility Impacts, is displayed in Figure 7. A complete list of the elements and their descriptions are presented in Appendix 2.

SECTION I. BASIS OF PROJECT DECISION	
A. Project Strategy A1. Need & Purpose Documentation A2. Investment Studies & Alternatives Assessments A3. Programming & Funding Data A4. Key Team Member Coordination A5. Public Involvement **B. Owner/Operator Philosophies** B1. Design Philosophy B2. Operating Philosophy B3. Maintenance Philosophy B4. Future Expansion & Alteration Considerations	**C. Project Requirements** C1. Functional Classification & Use C2. Evaluation of Compliance Requirements C3. Survey of Existing Environmental Conditions C4. Determination of Utility Impacts C5. Value Engineering
SECTION II. BASIS OF DESIGN	
D. Site Information D1. Geotechnical Characteristics D2. Hydrological Characteristics D3. Surveys & Planimetrics D4. Permitting Requirements D5. Environmental Documentation D6. Property Descriptions D7. Ownership Determinations D8. Right-of-Way Mapping D9. Constraints Mapping D10. Right-of-Way Site Issues **E. Location & Geometry** E1. Horizontal & Vertical Alignment E2. Control of Access E3. Schematic Layouts E4. Cross-Sectional Elements	**F. Structures** F1. Bridge Structure Elements F2. Hydraulic Structures F3. Miscellaneous Design Elements **G. Design Parameters** G1. Provisional Maintenance Requirements G2. Constructability **H. Installed Equipment** H1. Equipment List H2. Equipment Location Drawings H3. Equipment Utility Requirements

Figure 5. APRA Sections I & II, Categories, and Elements

SECTION III. EXECUTION APPROACH	
I. Acquisition Strategy	**K. Project Control**
I1. Long-Lead Parcel & Utility Adjustment Identification	K1. Right-of-Way & Utilities Cost Estimates
I2. Long-Lead/Critical Equipment & Materials Identification	K2. Design & Construction Cost Estimates
I3. Local Public Agencies Utilities Contracts & Agreements	K3. Project Cost Control
I4. Utility Agreement & Joint-Use Contracts	K4. Project Schedule Control
I5. Project Delivery Method & Contracting Strategies	K5. Project Quality Assurance & Control
I6. Design/Construction Plan & Approach	K6. Safety Procedures
I7. Procurement Procedures & Plans	**L. Project Execution Plan**
I8. Appraisal Requirements	L1. Environmental Commitments & Mitigation
I9. Advance Acquisition Requirements	L2. Interagency Coordination
J. Deliverables	L3. Local Public Agency Contractual Agreements
J1. CADD/Model Requirements	L4. Interagency Joint-Use Agreements
J2. Documentation/Deliverables	L5. Preliminary Traffic Control Plan
	L6. Substantial Completion Requirements

Figure 6. APRA Section III, Categories, and Elements

C4. Determination of Utility Impacts

Infrastructure projects often necessitate the adjustment of utilities to accommodate the design and construction of proposed transportation facilities. Failure to mitigate utility conflicts in the design process or to relocate facilities in a timely manner can result in unwarranted delays and increased project costs. Issues to consider include:

- ❑ Field verification of existing utilities facilities
- ❑ Field verification with proposed alignment
- ❑ Necessary utility facility repair and modernization
- ❑ Action plans for utility adjustments
- ❑ Physical constraints to utility placement
- ❑ Schedule impact of utility relocations and adjustments
- ❑ Determination of utility location in State right-of-way
- ❑ Local ordinances or industry standards
- ❑ Safety clearances requirements
- ❑ Other

Figure 7. Example APRA Element with Descriptions

4.2. Element Definition Levels

The description of an element provides the level of detail and work that needs to be performed pertaining to the element. All of the work is not necessarily done at all times during the entire project development process, and neither are all the details known in this period. Levels of definition are therefore used to indicate the level at which each element is defined at a given time, and this level is determined by comparing what is known about the element with its full description. This comparison is necessary for future assessment of each element's definition as well as the project's. A scale of five levels, from one to five, is used for this purpose. Additionally, a definition level of zero is used to indicate that an element is not applicable to a project for whatever reason. To adopt the words from the research by CII (2008a, 2008b), for those elements with minor deficiencies, no further work is needed during the PDP and the issue will not impact cost and schedule performance; for those elements with some deficiencies, major deficiencies or are incomplete, further investigation will need to be performed. The definition levels are described as follows and are anchored at the end of preliminary design:

- Level 1: The element is **completely defined**. The element is well defined. All of the work pertaining to the element is performed completely. There is no more work required.
- Level 2: There are only **minor deficiencies**. Only some minor work is needed for several items of the element.
- Level 3: There are **some deficiencies**. There is major work needed for some items, or some work needed for most of the items of the element.
- Level 4: There are **major deficiencies**. There is major work needed for most of the items of the element.
- Level 5: There is an **incomplete or poor definition**. The element is poorly defined. Major work is needed for all or almost all items of the element.

As described, definition level 1 is the desired status of an element while definition level 5 is the least preferred. This indication of preference level is not intended to mean that level 5 is categorically bad since the assessment of a level also depends on the time when the judgment is made. An element that is poorly defined at one stage of a project may become well defined in a subsequent stage.

4.3. Scope Elements Weighting

Different scope elements, even though all are critical, need to be weighted relatively according to their potential impact to a project. In this section the whole process of choosing the method, organizing, and performing the weighting activities will be elaborated upon more fully. How the data collected for the weighting were analyzed and the results from this analysis will also be presented in detail.

4.3.1. Organization for the Weighting Process

Tapping experts' knowledge using workshops was selected as the method by which to conduct the weighting. The research team wanted to involve as many experts from as many districts as possible to obtain the most practical and representative sample of experts from 25 TxDOT districts. Therefore, different areas in Texas were selected for organizing the multiple workshops. Each workshop involves people from the organizing district as well as nearby districts.

With help and support from the PMC members, the research team contacted R/W administrators of districts nearby the intended workshop locations and requested that they and their experts' participate in one of the workshops. The time for each workshop was selected to fit the schedules of as many district experts as possible. The next section provides details about the workshops that were organized, the numbers of attendees at each workshop, and the districts that participated.

In preparation for the workshop series, a workshop package was developed. A workshop would require a well-structured presentation on the method and how to weight each element since a great deal of information needed to be conveyed to the participants in a limited period of time. The participants would also have to concentrate on providing input into the weighting of elements. After much preparation, the research team developed a weighting workshop package that is comprised of the following documents, some of which are included in Appendix 3:

- Agenda. This provides an overview of tasks planned for each workshop. An example of the workshop agenda is included in Appendix 3.
- Introductory presentation. This presentation was designed to be presented in 45 minutes. Included in the presentation are an overview of the research and people involved, an overview of the APRA method, an introduction on how to weight the elements, and the future research path.
- Introduction to the APRA. This one-page document was prepared to give the participants an overview of the APRA that they can read before and after the presentation. This document is included in Appendix 3.
- Evaluation Instructions. This document gives detailed instructions about how to weight an APRA element. It was prepared to allow the participants something to refer to at anytime without reliance on the presentation. This document is included in Appendix 3.
- Background Information. Each participant was asked to provide some background information about their professional experience, such as how long they had been working in different areas of project development and what types of projects they had been involved in and in what capacity. Contact information was also collected through this form so that the research team could follow up with each expert if necessary. Each participant was asked to select a typical project that their organization has been involved with to use as a point of reference during the weighting process, and respondents were asked to provide basic background information about this project on the form. Appendix 3 includes this background information document.
- Weighting Form. This form consists of a table with a list of elements with five levels of definition for each element in a row. Participants would provide the elements' weights in the table. For each element, there is a column to the right for the experts to provide comments and suggestions regarding the element. This document is included in Appendix 3.

- Element Descriptions. This document contains the list of the elements with their comprehensive descriptions. It was included so the experts could refer to it while they weighted the elements. It is included in Appendix 2.
- Project Development Process Flowchart. This flowchart offers a general flowchart of the project development process used by TxDOT. It contains different phases and phase gates during that process. It was included to provide the participants with a reminder of the overall project development process. It is included in Appendix 3.
- Suggestions Form. This document was intended to obtain the experts' feedback on the elements and their descriptions as well as any comments and suggestions on the APRA method that was being developed.
- Unweighted Score Sheet. This document is a blank score sheet that contains elements and levels of definition in the format of a table. It was included so the experts could bring it back with them to work for future reference and possible use. It is included in Appendix 3.

The documents were color coded to facilitate effective communication. The documents that the research team intended to collect back were printed on paper of the following colors: Background Information sheets in green, Weighting Form sheets in yellow, and Suggestions Form sheets in pink. All other documents were on white paper and were intended for the participants to keep.

4.3.2. Weighting Workshops

From September 2006 to March 2007, six workshops were organized in five cities in Texas. Two workshops were held in Austin, but they were for different groups of TxDOT districts. As shown in Table 1, 51 participants from 12 districts attended the six workshops. The participants were from all disciplines in the project development process, including Programming and Planning, Design, ROW, Utility, Environmental, and Survey. The participants' experience ranged from a few years to more than 30 years. Many had held a variety of positions in their districts, including district engineer. This variety ensured that a wide range of experts' experience from various disciplinary perspectives would be taken into account in calculating the weights of the elements and that the expert group would be more representative of all TxDOT experts. In statistical terms, this purposive expert sample represented well the population from which it was selected.

Table 1. Weighting Workshops Conducted

Date	Location	District Participated	Number of Attendees
9/13/2006	Dallas District Office (Dallas, TX)	Dallas Forth Worth Tyler	10
10/25/2006	Abilene District Office (Abilene, TX)	Abilene Childress Odessa Lubbock	19
11/29/2006	TxDOT Austin Project Office (Pflugerville, TX)	Austin	4
01/17/2007	CTR Office (Austin, TX)	Bryan San Antonio	9
2/7/2007	Waco R/W Office (Waco, TX)	Waco	2
3/7/2007	Houston District Office (Houston, TX)	Houston	7
TOTAL		12 districts	51

Each workshop was designed for an entire working day, normally from nine in the morning to three in the afternoon. Lunch was provided in the meeting room to ensure maximum concentration of the participants and also to save time since people did not have to leave the room. Providing lunch between working sections also allowed time for more interactions among the workshop participants and the research team members. It proved to allow more discussion since people tend to be willing to discuss more and ask more questions in informal settings. In some cases, some people were not clear about the weighting process; the lunch break was the best time for them to catch up.

The workshops started with an introduction of the research team and the experts. Each person was asked to give a short introduction on his or her current work and past working experience. The introduction period was followed by a presentation by the research project team. The presentation started with an introduction to the research project, its objectives, and the research team and TxDOT people who were involved in the project in monitoring roles. The presentation continued with a brief background review on research studies and findings relevant to the topic. This part focused mainly on research efforts by CII to create the Project Definition Rating Indexes for industrial and building projects. Then the workshop participants were introduced to the APRA method, its ongoing development, and its expected benefits, with an emphasis on the element list and descriptions generated. Following the introductions, the APRA weighting method was the main part of the workshop. The final part of the presentation provided an overview of the research project's future steps after the workshop series; this part was presented at the end of each workshop, after the element weighting had been done.

After the introductory presentation, the experts were asked to select a project among those that they had been involved in and use this as a reference point for the entire weighting process that would follow. This project should be typical in terms of both its type and size in their organization (district in this case.) A typical project is more likely to better represent a district's pool of projects. The experts were reminded that they should not try to choose a more or less successful project for consideration but rather to select a typical project. An alternative approach to this focus on one project for consideration would be to use the entire experience of the experts. However, using only one typical project was the preferred choice because of the following reasons:

- Using only one project allows for a better evaluation of the relative impacts of risk issues within the scenario of that project. If the entire experience of a person is used, he or she would likely tend to use the worst case among all the projects for each element. Relying on such worst case projects could result in too many elements rated as having high impacts because different projects have different important issues. This fact would make the weighting reflect the relative importance of elements inaccurately.

- One could argue that using only one project could make the evaluation biased and fail to take into account all the experience of the experts. The former concern can be addressed by using many different projects provided by different experts. Having different types of projects will eliminate much bias that may result from using one project. The latter concern is questionable since in considering the weight for each element, an expert would take into account not only the context of the project, but also his or her entire experience with similar issues in similar projects.
- Using a single project for each participant allows for a clearer analysis and inference of relations among variables such as project size, project type, project's level of success, participant's experience, participant's area of work, and element characteristics.

Weighting Mechanism

At the beginning of the weighting session, the participants were asked to provide background information about themselves as well as about the project they selected on a green form.

Each participant was then asked to assume that he or she was estimating the selected project at the time when the project was about to undergo the detailed design process (Plans, Specifications, and Estimates.) One element was to be considered at a time. For each element there were two scenarios. First, if the element, as described in the Element Descriptions document provided, was poorly or incompletely defined, the experts were asked how much contingency they would assign to that element. An element was considered poorly or incompletely defined when, in comparison with its provided description, none or little of the work had been done by the project team.

A contingency is an amount of money used to offset uncertainties related to all aspects of project execution. The participant was asked to take into consideration both time and cost effects as the result of poor definition of the element when determining a contingency; both types of effects should be converted to a monetary value. The contingency should be put in terms of percentage of the project's total installed cost. The contingency selected should be written in the table cell corresponding to element definition level five on a yellow form.

The second scenario was when the element was completely defined. Logically, when the element is more defined, less contingency should be assigned to it to offset the uncertainties it may bring to the project during its execution. This second value should be written in the cell that corresponds to definition level one of the element. This process was used for all elements on the list. The participants were all reminded that they could make changes at any time to the weights of the elements they had assigned before if they felt it necessary; they would also be given some time at the end of the workshop to make such adjustments.

The contingencies assigned for a poorly defined element would be used to calculate the score for definition level five of that element. This score is the maximum score an element can have, and it denotes the weight of the element. The more weight the element has, the more important it is to a project. Likewise, the contingencies for the well defined element were used for calculating the score of definition level one. Note again that level one is the desired level of definition when an element is well defined. However, the score of level five determines the importance of an element.

During this whole weighting process, the research team maintained the pace while all participants went element by element in the workshop to make sure all questions and concerns were raised and answered before the whole group would move to the next element.

It is not unusual for an element to be not applicable to a project regardless of its size. In this case, the expert is asked to write "N/A" in both places for levels of definitions one and five of that element. They are reminded not to write "0" for non-applicable elements because a "0" level of definition means an applicable element that at that level of definition does not cause any uncertainties to the projects and thus poses no inherent risk.

If an element was applicable to the project but the participant was not familiar with it, the participant was asked to use his or her general experience to judge the weight for that element in a project with similar characteristics. Again, this case should be well distinguished from a non-applicable element where the project was considered as having no work pertaining to that element.

In the final part of the workshop, time was set aside for the participants to discuss with and provide any feedback to the research team regarding any aspects of the elements, the descriptions, the weighting process, and the APRA method. They were also asked to answer questions and write any comments and suggestions they may have had on the provided pink suggestions form. Specifically, they were asked to provide opinions on the following items:

- The completeness and possible redundancy of the element list;
- The clarity of the element descriptions;
- The instructions to weight the elements;
- How to improve the APRA method;
- Questions asked in forms in the package handed out;
- The method to obtain experts' knowledge and experience used in the workshops;
- Any other general issues.

All of the color-coded forms (green background information, yellow weighting sheets, and pink suggestions forms) were collected by the research team. All other white documents were for the participants' reference and use.

4.3.3. Analyzing Workshop Data

Data collected from the workshops are both qualitative and quantitative in nature. Qualitative data are from the comments and suggestions the participants made during the workshops, especially in the suggestions form at the end of the workshops. Most of the experts who participated in the workshops agreed that the list and descriptions of the elements were comprehensive and thorough. There were some suggestions to include some more issues somewhere in the list. The research team has made some appropriate changes to some elements' descriptions to accommodate these reasonable suggestions. All the changes of this type pertained to adding some issues to the list of issues to be considered in several elements.

Some participants suggested combining several elements. However, the research team considered the suggestions and believed that some elements may seem to deal with a similar issue, but they actually address the issue at different points of time during the project development process and from different perspectives. Some level of overlap among the elements is both inevitable and acceptable due to the interrelation and repetition of the work in some functions. If the elements were combined, they would not cover the issue completely. The research team, therefore, decided to keep the elements as they were.

There were also some comments on and suggestions about clarifying some questions on the forms. Having found these suggestions reasonable, the team has made some changes on the forms. These changes were considered minor and were not believed to affect the quality of the data intended to be collected.

The majority of data collected from the workshops are quantitative in nature, and they are written on the background information sheets and weighting forms. The quantitative analysis of the data is detailed in the following sections.

Preliminary Screening of Data

There were a total of 51 participants in the six organized workshops. The terms "participant," "expert," and "professional" will be used interchangeably to indicate those experts who participated in this research, in workshops, interviews, or meetings. Their weighted forms were assigned a code based on the workshop location. For each workshop location, the forms received were numbered sequentially. These forms needed to be screened before being used to calculate the final weights of the APRA elements. Out of these 51 weighting forms received, two of them were incomplete with a significant amount of missing data, and thus they were discarded from further use. The 49 forms left were then entered into a spreadsheet using Microsoft Excel for analysis. Of the 49 forms, three belonged to participants who had less than three years' experience, and these were considered unsuitable for use in calculating the elements' weights. Thus, after the preliminary data screening, 46 data sets from 46 experts were qualified for inclusion in further data analysis.

Basic Information on Weighting Workshop Participants

The remaining 46 experts had expertise in all seven major areas of project development: ROW and Utilities, Planning and Development, Environmental Affairs, Design, Project Management, and Surveying Services. Their participation was representative of the expertise areas typically involved in transportation infrastructure projects; Figure 8 illustrates the distribution of their disciplines. The participants' experience had a wide range of distribution, from three to 31 years with an average of 18 years. Five of the participants had less than 10 years of experience, 25 with 10 to 20 years, and 16 with more than 20 years. Figure 9 presents the distribution of the experts' experience; the vertical bar on the right hand side represents the average number of years' experience.

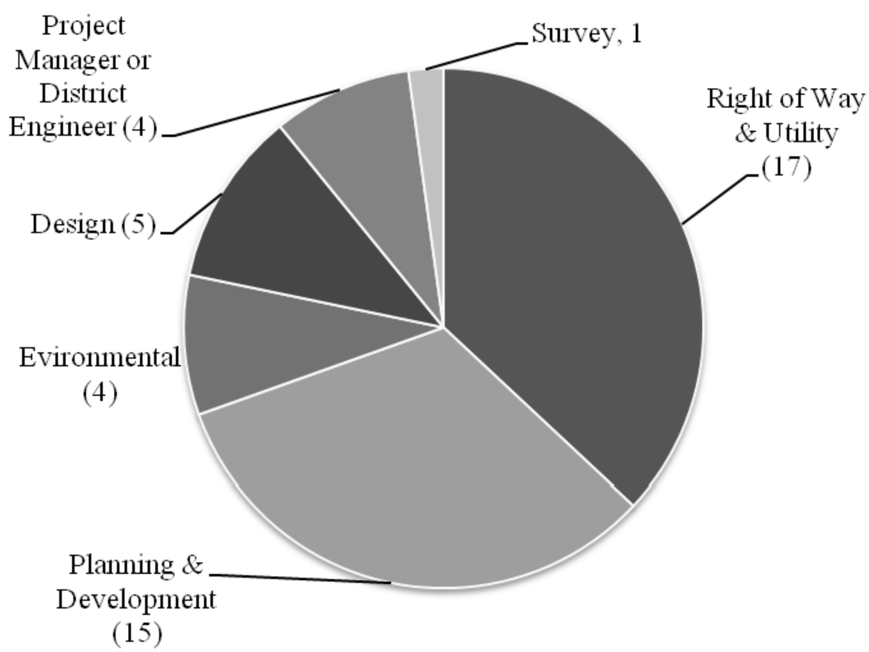


Figure 8. Distribution of Participant Disciplines after Preliminary Data Screening (N = 46)

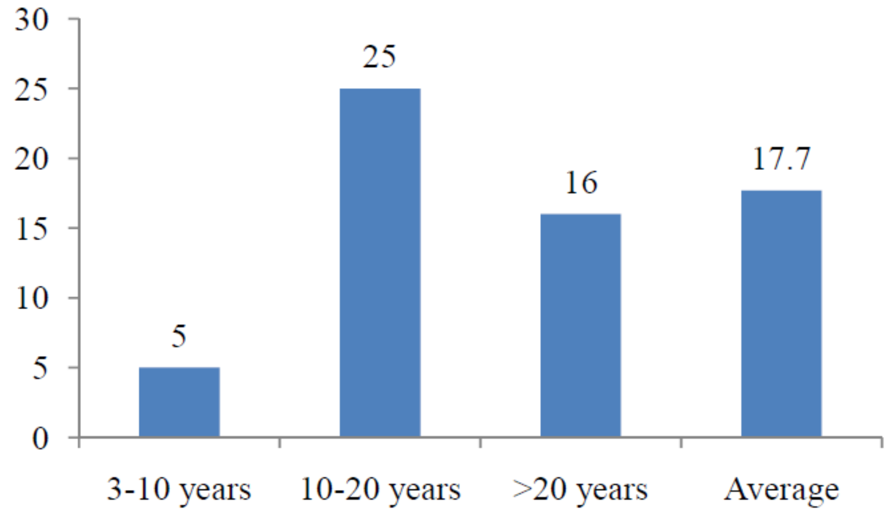


Figure 9. Distribution of Participant Years of Experience (N = 46)

Characteristics of Projects Used for Weighting Elements

As aforementioned, each expert was asked to select a typical project in his or her district to use for reference in weighting elements. Project characteristics were captured on the Background Information sheet in the workshop package. Figure 10 shows the distribution of the types of projects used for weighting the elements. It should be noted that the total number of projects in all types shown in Figure 10 is 47 instead of 46; this is because one project was characterized as both a rural and urban renovation/expansion project. Most of the projects were renovation or expansion (33 out of 46). There were 14 projects that involved new construction. Thirty one projects were in urban areas while 16 of them were considered rural. This distribution reasonably represents different types of projects in Texas.

Figure 11 presents the distribution of the projects' total installed cost (TIC). The projects' TIC ranges widely from less than $5 million to more than $100 million. This wide distribution was expected, and it increases the applicability of the weighting results to projects of various sizes.

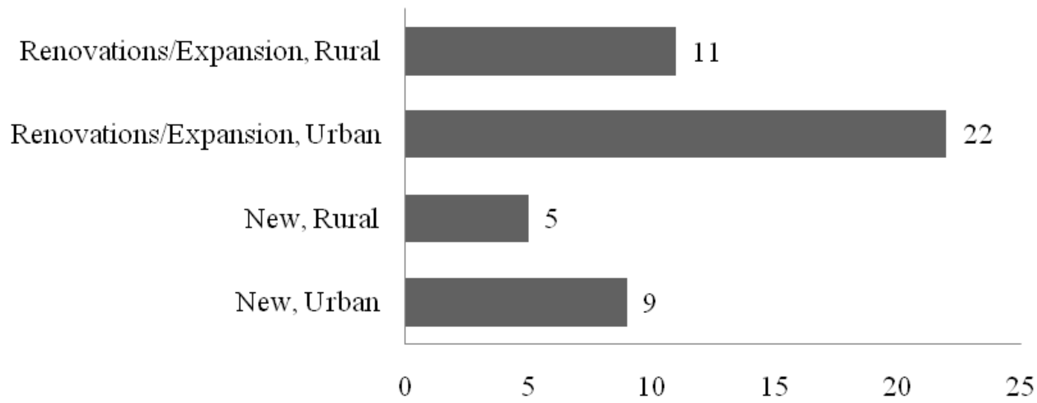


Figure 10. Type of Projects Used for Weighting Elements (N = 47)

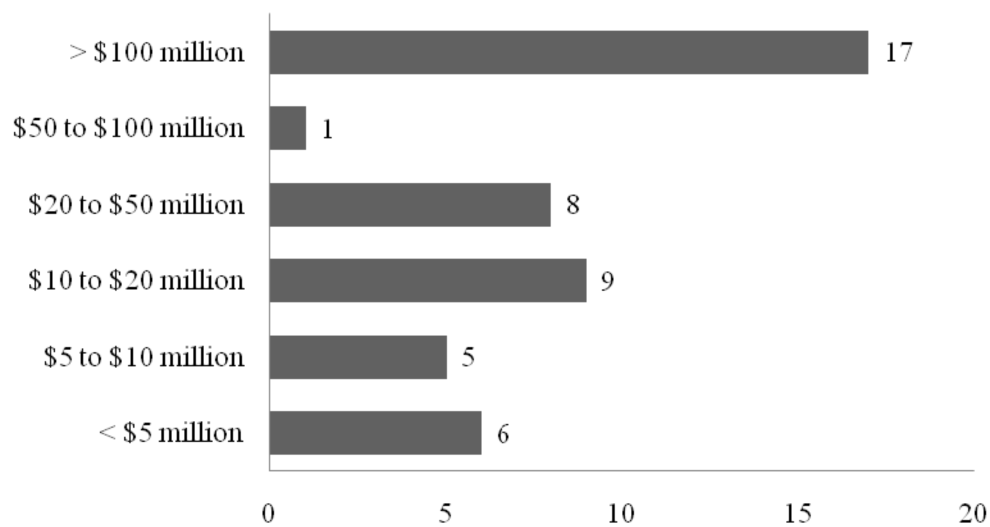


Figure 11. Total Installed Cost of Projects Used for Weighting Elements (N = 46)

Normalization of Elements' Weights

At the workshops, the participants were asked to assign weights to elements based on the consideration of the contingency needed to offset the uncertainties each element may bring to the project later. The elements' weights were considered relatively compared to one another. At the end of the weighting process, the experts were allowed to adjust the weights. These contingencies were highly subjective to the experts' opinions and were not restrained to any limit. In order to calculate the final elements' weights, a number of steps needed to be performed, one of which was normalizing the weights. The purpose of the normalization step was to make scores assigned by all experts comparable so that they could be used for calculating by averaging the final weighting of the elements. The total score of all the elements' weights by all experts would be scaled to a common level of scores with the all other experts.

This research was modeled after similar research efforts by CII that led to the creation of PDRI for industrial and building projects. Due to the effectiveness of the PDRI in other sectors and in order to allow for comparative analysis among industrial, building, and transportation infrastructure sectors, a similar score range from zero to 1000 was chosen for normalizing the raw weights assigned by the experts. This is the maximum score of the whole project, and it is obtained by adding up the scores of all the elements. A score close to or at 1000 denotes a project that is very poorly or incompletely defined. In contrast, a score of zero or close to zero means that a project is well or completely defined.

The maximum score of 1000 is obtained by adding up the maximum scores of all the elements. The normalization is done for each data set (each weighting form) completed by each participant. For each data set, the normalization process began with the researchers adding up the scores of all the elements corresponding to definition level five. It should be noted that this was one of the two scenarios that the experts were asked to consider when weighting the elements; the other scenario was when all elements have a definition level of one. The result would be a total score that is likely to be different from 1000. A normalizing multiplier was calculated by dividing 1000 by the total score obtained through adding up the weighted elements. Each element's score (corresponding to definition level five) was then multiplied by this normalizing multiplier to obtain a normalized score. The result of adding all normalized scores of all elements is 1000. This process was performed for all the data sets, and the results were an identical total score of 1000 for all participants.

When an element was deemed not applicable in a project by a participant, "N/A" would be marked in the table cells for both definition levels one and five. This element would then be eliminated from the normalization process for that particular participant's data set.

Each element has two definition levels, one and five, that were assigned a weight by each participant. The normalization of definition level five's scores has been explained above. As for definition level one, the same normalizing multiplier that was obtained from normalizing definition level five was used. The score of each element's definition level one was multiplied by the multiplier to obtain a normalized score. Scores of all elements (of each participant) were then added up to get a total score corresponding to definition level one. These scores should be much lower than 1000 points since it represents the case when all applicable elements are well defined. The normalized scores in both cases (definition levels one and five) would be used for further data screening which is explained in the next section.

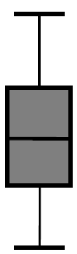
Appendix 4 presents an example of how scores assigned by a participant were normalized. First the scores that the participant assigned to the elements with (definition) levels of one and five were entered into the columns under "Original Weight." The elements' scores at level five were then added up to make the "Total of Level Five Scores," with the value of 1130. Then 1000 would be divided by this value of 1130 to get a multiplier of 0.885. This multiplier was used to multiply with the corresponding scores for all elements at both levels one and five. The new scores were then entered into the columns under the heading "Normalized Weight." These are the normalized scores that would be used later for further data screening and calculating the elements' final weights. If all the scores under the level five column are added up, the result will be 1000. The total score of those under the level one column is 114. This last total score in this example case is not necessarily identical to those of the other participants.

Screening Data Using Boxplot Technique

For a sample to be reasonably representative of the entire population, it is necessary to eliminate those values that could seriously skew the distribution of the sample. It is no exception when calculating the weights of the APRA elements. These weights were calculated using the normalized scores obtained from the normalization process described in the previous section. The objective was to eliminate weights from participants who had a significant number of answers (scores) that were outliers in comparison to others' responses. In order to do that, it was necessary to conduct an analysis of the scores assigned by all 46 participants to each element at each level of definition to identify both the outliers and who they belonged to. That said, there would be 92 analyses of this type for the 46 elements with 2 definition levels each.

The boxplot technique was selected to perform these analyses for two main reasons. First, the boxplot technique uses mainly median, upper and lower quartiles that are not affected by extreme values in a distribution (Cooper and Schindler 2003). Specifically, values of up to 50 percent of the data points at the two ends (25 percent each) of a distribution do not affect the values of the median, upper, and lower quartiles. This feature makes the three statistics reliable in scanning extreme values in a distribution. Second, with a sample of 46 datum points, it is less likely to have a normal, or nearly normal, distribution, and this lack means that other methods, such as using mean and standard deviation, cannot be used effectively; the boxplot technique is a better choice in this case.

Figure 12 illustrates concepts associated with the boxplot technique. A boxplot has two hinges, the lower is at the lower quartile (25^{th} percentile), and the upper is at the upper quartile (75^{th} percentile.) The horizontal line in the middle of the boxplot signifies the median value. An interquartile range (IQR) is the difference between the upper quartile and the lower quartile. A datum point is a mild outlier if it is more than 1.5 times the IQR from either the upper or lower quartiles. An extreme outlier would be a value that is more than 3 times the IQR from either the upper or lower quartiles (Devore 2000).



*	Value more than 3 IQR bigger than upper quartile (extreme outlier)
O	Value more than 1.5 IQR bigger than upper quartile (mild outlier)
	Highest value that is within 1.5 IQR from upper quartile
	Upper quartile (75th percentile)
	Median
	Lower quartile (25th percentile)
	Lowest value that is within 1.5 IQR from lower quartile
O	Value more than 1.5 IQR smaller than lower quartile (mild outlier)
*	Value more than 3 IQR smaller than lower quartile (extreme outlier)

Figure 12. Annotated Sketch of Boxplot

The SPSS software package version 13.0 was used to perform the analyses using the boxplot technique. An analysis is done for definition levels one and five for each of the 46 elements, which means that 92 boxplots needed to be created. Figure 13 presents examples of boxplots for all elements in category A (from A1 to A5) with the definition level five. A boxplot is determined by the median, upper quartile, and lower quartile. Each boxplot for an element may have mild and extreme outliers that are denoted by a circle and an asterisk, respectively. Each of these outliers corresponds to the weight that a workshop participant assigned to that element at that definition level. For example, in Figure 13, element A5 (at definition level five) has two outliers, one mild outlier assigned by a person with the ID of AB18, and one extreme outlier assigned by a person with the identification number of DL7.

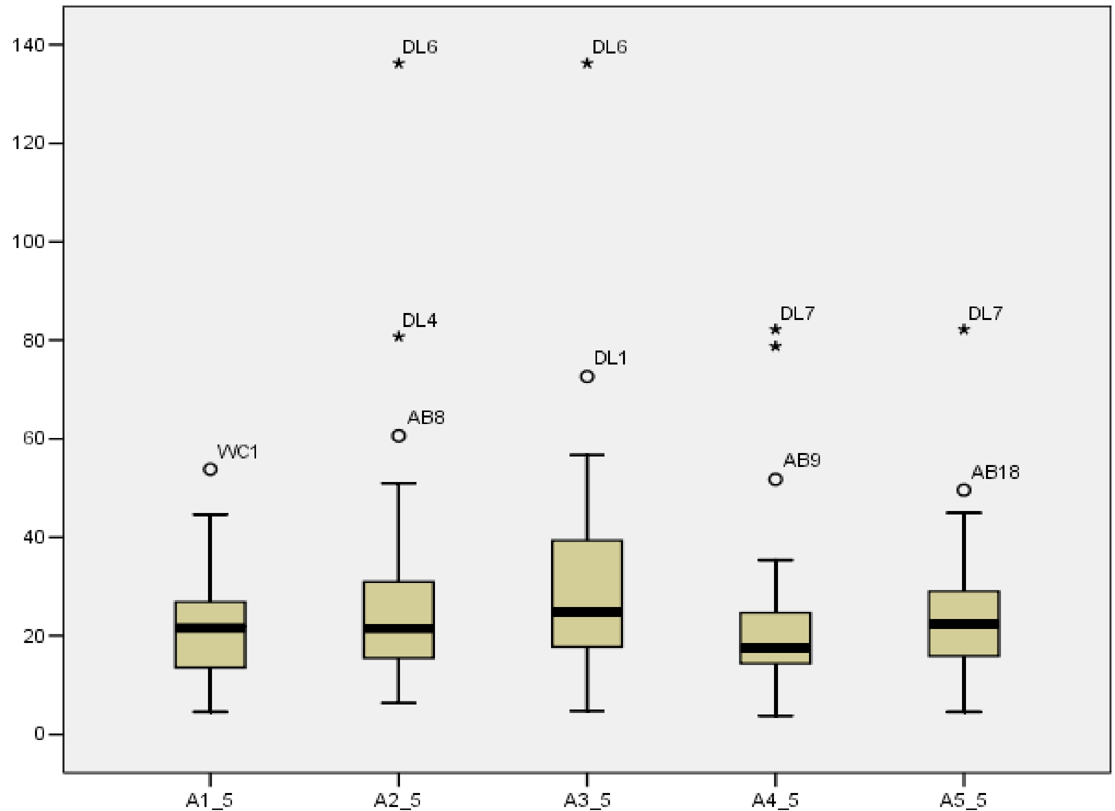


Figure 13. An Example for Identifying Mild and Extreme Outliers

Not all the participants results that have outliers would be discarded, but only those with significant numbers of outliers. In order to screen these participants out, an index called a frequency index is used. It is calculated using the formula below. In this formula, extreme outliers are weighted three times as much as mild outliers.

$$\textit{Frequency Index} = 3 \times \textit{Number of Extreme Outliers} + 1 \times \textit{Number of Mild Outliers}$$

After all 92 boxplots had been generated, frequency indexes were calculated for all 46 participants. Outliers in both levels one and five are included in calculating the index. For example, participant DL1 had one extreme outlier and four mild outliers, and thus had a frequency index of seven. Seven participants who have a frequency index of 20 or higher were discarded. The research team believed an index of 20 is a reasonable cutoff point. It is equivalent to a combination of five mild outliers and five extreme outliers (out of 59 elements). A cutoff of 17 would result in the exclusion of eight participants, and a cutoff of 22 would result in the exclusion of six participants. This cutoff point is also commensurate with those in the CII's research on the flagship PDRI. As a result, weights from 39 participants were kept for calculating the final element scores. This number of datum points was believed to provide a reasonable representation of the entire expert population. Table 2 presents the outlier frequency indices.

Table 2. Outlier Frequency Indexes of Workshop Participants

Participant	DL1	DL2	DL3	DL4	DL5	DL6	DL7	DL8	DL9	DL10
Extreme Outliers	1	1	2	6	1	1	0	1	4	6
Mild Outliers	4	4	0	11	1	2	0	1	5	6
Frequency Index	7	7	6	29	4	5	0	4	17	24
Participant	**AB1**	**AB2**	**AB3**	**AB5**	**AB6**	**AB7**	**AB8**	**AB9**	**AB11**	**AB13**
Extreme Outliers	0	0	0	0	0	3	0	9	0	0
Mild Outliers	0	1	1	2	0	4	0	7	1	0
Frequency Index	0	1	1	2	0	13	0	34	1	0
Participant	**AB14**	**AB15**	**AB16**	**AB17**	**AB18**	**AB19**	**AU1**	**AU2**	**AU3**	**AU5**
Extreme Outliers	1	0	3	0	2	0	0	2	1	0
Mild Outliers	4	5	2	1	7	1	1	12	0	1
Frequency Index	7	5	11	1	13	1	1	20	3	1
Participant	**AU6**	**AU7**	**AU8**	**AU9**	**AU10**	**AU11**	**AU12**	**AU13**	**WC1**	**WC2**
Extreme Outliers	1	0	0	0	0	7	3	1	0	0
Mild Outliers	0	3	0	0	1	5	13	2	5	1
Frequency Index	3	3	0	0	1	26	22	5	5	1
Participant	**HT01**	**HT02**	**HT03**	**HT04**	**HT06**	**HT07**				
Extreme Outliers	5	0	0	0	1	3				
Mild Outliers	11	0	1	0	4	7				
Frequency Index	26	0	1	0	7	16				

4.3.4. Finalizing Element Weights

After the data went through the preliminary data screening and statistical data screening using the boxplot technique, the next step was to actually calculate the weights of the elements that are used for the APRA method. Following sections will provide more details on this process.

Element Weights Calculation for Definition Levels 1 and 5

After the data screening, each element had 39 weight values from 39 participants for each definition level, 1 and 5. Some of these might not have a numeric value because of non-applicable elements in some projects; these would be eliminated from calculation of element weights. The weight of an element at a definition level was obtained by averaging the weights from all 39 (or in some cases fewer) values corresponding to the 39 participants. This was done for both levels 1 and 5. These became the preliminary weights of the elements.

An expected result from summing up all preliminary weights of the elements at definition level 5 was that the total score would be greater than 1000. This is due to the fact that in some cases when averaging the participants' weights to obtain an element's preliminary weight, the denominator was smaller than 39 due to the existence of non-applicable elements (in those participants' projects.) If none of the projects had had non-applicable elements, the result would have been 1000. The total score obtained was 1056. The element weights were re-normalized so that their total score would be 1000 using the similar process that was used in the normalization.

Similar to the selection of 1000-point scale for definition level 5, the selection of scale for definition level 1 was chosen to ensure the comparative analysis among industrial, building and transportation sectors. The total score of a project when all elements have the definition level of 1 was therefore selected to be 70 as used by these CII Indices. The total score of all elements at definition level 1 after the normalization was 139. The same normalization principle was used to renormalize these scores. A multiplier of 0.502 was obtained by dividing 70 by 139. It was used to re-calculate the element scores at definition level 1. The obtained scores for both definition levels were then rounded and adjusted. After this adjustment, the elements' scores at definition levels 1 and 5 were final; they all add up to 70 and 1000, respectively.

The element scores at definition level 2, 3, and 4 were not determined directly from workshop data. They were intermediate values and could be linearly interpolated from the two values at definition levels 1 and 5. The following formulas were used to calculated weights of definition levels 2, 3, and 4:

Level 2 Weight = Level 1 Weight + (Level 5 Weight – Level 1 Weight)/4

Level 3 Weight = Level 2 Weight + (Level 5 Weight – Level 1 Weight)/4

Level 4 Weight = Level 3 Weight + (Level 5 Weight – Level 1 Weight)/4

Each score was then rounded to the closest integer and became final score for use in the APRA method. The results from the calculation for definition levels 1 and 5 and linear interpolation for definition levels 2, 3, and 4 are presented in Appendix 5.

Final APRA Project Score Sheets

The interpolation of element weights for definition levels 2, 3, and 4 completed the APRA element weighting process. Detailed final APRA weighted project score sheets for Sections I, II, and III are presented in Appendix 6.

4.3.5. Analysis of APRA Element Scores

An element has the highest score when it has definition level of 5. This highest score represents the importance of the element; the higher the score, the more important the element is to a project. A category has the maximum score when all of its elements have their maximum scores. This maximum score also illustrates the relative importance of the category when compared with other categories. Likewise, highest scores of all categories in a section will cause it to have the maximum score. And of course, maximum section scores add up to project maximum score, which is 1000. Figure 14 shows the weights of all categories and sections.

Interestingly, weights of the three sections are fairly even, from 30 percent total weight for Section I to less than 36 percent total weight for Section II. This implies that in a transportation infrastructure project, basis of project decision, basis of design and execution approach contribute relatively equally to the outcome of the project. Section I, Basis of Project Decision, consists of information necessary for understanding the project objectives. The completeness of this section determines the degree to which the project team will be able to achieve unification in meeting the project's business objectives. Section II, Basis of Design, consists of geotechnical, hydrological, environmental, structural, and other technical design elements that should be evaluated to fully understand impacts on the acquisition of R/W. Similarly, this section includes a number of R/W requirements prior to acquisition, occurring simultaneously with preliminary design. Finally, Section III, Execution Approach, consists of elements that should be evaluated to fully understand the requirements of the owner's execution strategy and approaches for detailed design, R/W acquisition, utility adjustments, and construction.

SECTION and Category	Weight
SECTION I – BASIS OF PROJECT DECISION	300
Category A - Project Strategy	122
Category B - Owner/Operator Philosophies	76
Category C - Project Requirements	102
SECTION II – BASIS OF DESIGN	359
Category D - Site Information	173
Category E - Location & Geometry	79
Category F - Structures	48
Category G - Design Parameters	29
Category H - Installed Equipment	30
SECTION III – EXECUTION APPROACH	341
Category I - Acquisition Strategy	137
Category J - Deliverables	23
Category K - Project Control	98
Category L - Project Execution Plan	83
TOTAL	**1000**

Figure 14. APRA Section and Category Weights (at Definition Level 5)

A closer look at the weights of the categories reveals that category D, Site Information, is the most highly weighted, followed by categories I and A. The category with the lowest weight is category J, Deliverables. While attention should be paid to the highly weighted categories, the project team should not be misled by the low weights of some categories since most of the lowly weighted categories have only a few elements, and during the weighting process, it was the elements that were weighted, not the categories themselves.

Another approach is to analyze the most highly weighted elements. Figure 15 lists the ten elements with the highest weights. The total weight of these elements is 250, equivalent to 25 percent of the weight of all the elements. These are the elements that need more attention paid to them by the project team during project development. However, these elements weights represent only 25 percent of all the elements, thus by no means should they be considered the only elements that need attention. The rationale behind this caveat is that the 59 elements vary slightly from one element to the next important one, and many of them have the same weights. As can be seen in Appendix 7, in which all the elements are listed in descending order of their weights, the next three elements after element D5 (the last one in the top ten list) have the same weight, which is only one point smaller than that of D5. Note that element scores range from 8 to 30, with the lowest weight belonging to H2 "Equipment Location Drawings."

Figure 16 includes elements with the highest weights in each category. Categories K and L have two and three elements, respectively, that have elements that are tied for the highest position. This list may suggest paying the greatest attention to the most highly weighted element in each category. However, as with the top 10 elements list, these 15 elements should not be the only ones to be properly addressed.

Element ID	Element Name	Weight
C4	Determination of Utility Impacts	30
A3	Programming & Funding Data	30
C3	Survey of Existing Environmental Conditions	26
A2	Investment Studies & Alternatives Assessments	25
I1	Long-Lead Parcel & Utility Adjustment Identification	24
E3	Schematic Layouts	24
B1	Design Philosophy	23
A1	Need & Purpose Documentation	23
A5	Public Involvement	23
D5	Environmental Documentation	22
TOTAL		250

Figure 15. Ten Most Highly Weighted Elements

Category	Element ID	Element Name	Weight
A	A3	Programming & Funding Data	30
B	B1	Design Philosophy	23
C	C4	Determination of Utility Impacts	30
D	D5	Environmental Documentation	22
E	E3	Schematic Layouts	24
F	F2	Hydraulic Structures	18
G	G2	Constructability	18
H	H3	Equipment Utility Requirements	13
I	I1	Long-Lead Parcel & Utility Adjustment Identification	24
J	J2	Documentation/Deliverables	13
K	K1	Right-of-Way & Utilities Cost Estimates	21
	K2	Design & Construction Cost Estimates	21
L	L1	Environmental Commitments & Mitigation	15
	L2	Interagency Coordination	15
	L3	Local Public Agency Contractual Agreements	15
		TOTAL	302

Figure 16. Fifteen Most Highly Weighted Elements in Each Category

4.3.6. Interpretation of APRA Element Scores

A low APRA score represents a project scope that is well-defined, and, in general, corresponds to an increased probability for project success. Remember, the weights are based on the potential budget and time impacts of the element to the target project. Higher scores signify that certain elements within the project scope lack adequate definition.

The project total scores would be approximately 70, 300, 550, 775, and 1000 points if all elements had the definition levels of one, two, three, four, and five, respectively. At the beginning of the project development process, during the Needs Assessment phase, the project score can be close to 1000 points. As the project progresses into later phases, the project score should get lower. The lowest possible score of a project without non-applicable elements is 70, which becomes the case when all of the elements have a definition level of one.

Scoring is a subjective process, and each organization and sub-unit is unique. Thus, TxDOT may wish to keep its own database of APRA scores for various project sizes and types. As more projects are completed and scored using the APRA, its ability to predict the probability of success on future projects should improve. The APRA may serve as a gauge to assist an organization in deciding whether or not to authorize the development of PS&E and ultimately the construction of a project. TxDOT may also wish to use the database as an external benchmark for measurement against the practices of other organizations.

The APRA is of little value unless the project team takes action based on the resulting analysis and uses the assessment to identify and mitigate risk for the project under consideration. Among the potential uses when analyzing the APRA score are the following:

- Tracking project progress during the project development process, using the APRA score as a macro-evaluation tool. Individual elements, categories, and sections can be tracked as well.
- Comparing project-to-project scores over time to identify trends in developing scope definition within a particular organization.
- Comparing different types of projects (e.g., urban vs. rural; bridge vs. intersection; or new vs. rehabilitation) can allow TxDOT to determine its threshold APRA scores for those projects and identify critical success factors from that analysis. The APRA also can be used to compare projects for different organizations or different project sizes within the same organization.
- Looking at weak areas of the project at the section, category, or element level can yield important insights. For example, if an element has a definition level of three,

four, or five, the project team should either further define this element or develop a risk mitigation strategy. This provides an effective method of risk analysis since each element, category, and section is weighted relative to the others in terms of potential risk exposure. The identification of the project's weak areas is critical as the project team continues its progress toward execution and should provide the path forward of action to be taken by the project team.

- Another method of evaluation is to look at the score of each Section or Category as a percentage of its maximum score in order to focus attention on critical items for the project. For example, if the score for Section I, the Basis of Project Decision, is 150 points, then it is at 50 percent of its potential maximum score (300). The elements in this Section need much work.
- Note that the total score is divided fairly evenly among the sections. This distribution implies that attention should be paid to all sections even though at different phases of the project different sections may have different levels of definition.
- Sometimes, project teams are pressured to develop a scope of work in a short period of time. To streamline the process, the team could focus on the top ten elements, as listed in Figure 15. However, this approach should be used with the awareness that the weights of all elements are fairly evenly distributed. A description of each of the top ten elements can be found in Appendix 2.

4.4. Testing of APRA on Real Projects

Although the expertise from experienced professionals has been tapped in developing the weights of the elements, the APRA still needed to be tested on real projects to verify its viability as a method. This testing would allow for the understanding of how the APRA works in a real project environment, what benefits it can bring to the project, and what feedback practitioners had about its use. The testing would be performed on projects from as many areas (districts) as possible to provide a diverse test project portfolio and improve the representativeness of the sample of the project population. Both completed and ongoing projects would be selected for testing the APRA. This chapter will present in detail the APRA test process and its results.

4.4.1. Organization for Test Process

In order to test the APRA, in parallel with inquiring about districts' interests in providing projects and hosting meetings, a test document package needed to be developed. Each test meeting was planned to last approximately two and a half hours. During this time, the research team needed to provide an overview on the research project and the APRA method and the computer tool. The meeting participants needed to be informed of what was expected of them and how they could help testing the APRA. Then most of the time would be spent on actually testing the APRA on the selected project and on the participants providing feedback on the method and the tool. For the testing to accomplish this long list of tasks, the test package needed to be both well organized and effective. With help from the PMC members, the package was developed by the research team. Appendix 8 provides details about the package documents that have not been provided elsewhere in this report. What follows are short descriptions of each of the documents:

- Agenda. It provides an overview of the tasks to be fulfilled during the meeting within a planned time frame. An example of the agenda is included in Appendix 8.
- Presentation. This presentation was designed to be 45 minutes long. The presentation includes an overview of the research process and its products (the APRA method and the computer tool,) the next research steps, and instructions on how to test the APRA on a project.
- Test Questionnaires. The test questionnaires are the principal tool for the participants to provide information during the entire testing process. There are two versions of the questionnaires, one for completed projects and one for ongoing projects, as different background information was needed for each type of project. In both versions, the questionnaires include four parts. The first part is an introduction to the research and its process to familiarize the participants with what they were about to be involved. The second part asks the participants to provide

their professional background information and project information, including basic descriptive information and data on project costs, time, and change. The third part includes short instructions on how to assess a project and a project rating information sheet for the participants to enter the assessment results. The final part is for follow-up purposes; the participants should provide information on who participated in the test and how much time they spent on it. A copy of both questionnaire versions is included in Appendix 8.

- Element Descriptions. A copy of the Element Descriptions document was included for the participants to use in assessing each APRA element. This document can be found in Appendix 8.
- Post-Test Questionnaire. This questionnaire was used to obtain the test participants' general comments as well as their opinions about how the APRA can be of benefit to the project team during project development. A copy of this questionnaire is included in Appendix 8.

4.4.2. Testing APRA on Real Projects

Both completed and ongoing projects were selected for testing the APRA. The term "project" was meant to include all phases, from initiation to construction. A completed project is a project for which construction is completely finished. In contrast, an ongoing project is a project that has not been let and can be at any point prior to letting.

The research team contacted twenty districts to request their help in testing the APRA by providing projects for testing and hosting a meeting in a location convenient to them. Fourteen of the contacted districts expressed interest. Eleven districts actually participated in the test while the other three could not participate because the research team and the district could not arrange for meetings. Of the 11 districts, one performed the test on their own due to the involvement in and familiarity of the district's people with the APRA method and its development. From May to August 2007, the APRA was tested on seventeen projects, nine of which were completed projects and eight ongoing. A total of 32 experts from all disciplines in project development (including ROW, Utilities, Design, Environmental, and Planning) participated in the test of the APRA on the projects. They provided a great deal of insightful commentary and feedback on the APRA method during the testing process. Of the seventeen projects provided, one was in the construction phase and thus not qualified to be considered as one of the two project types defined. Its results were discarded from any further data analysis.

Preparation for Test Meetings

For each test meeting, the contact person of the hosting district was asked to invite from two to five people, who were actually involved in the project to attend the meeting, and these people would preferably be from different disciplines. More people were encouraged to attend the meeting if they could. The contact person was also sent a copy of the test questionnaire and requested to fill in as much project background information as possible prior to the meeting. This part was not necessarily completely filled out since often times the person needed to consult other people for project information, especially information related to project cost and time, and they could finish that part later after the meeting.

Test Meetings

The research team facilitated 7 of the meetings (on 7 projects), which lasted from one and half to three hours. The other projects were tested mainly by TxDOT's project teams. Each facilitated test meeting usually started with an introduction of the meeting participants and an overview of the project characteristics and status. The meeting then continued with a 30-to-45-minute presentation by the research team on the APRA method, its development, and how to test the APRA on a project. The participants were encouraged to raise any questions they might have on the APRA and how to test it. After the presentation, the actual test of the APRA was performed.

The test was done by assessing the level of definition of each of the 59 APRA elements. The following are the steps for assessing an element for a completed project:

- Read the element's definition in the "APRA Elements Descriptions" document. Some elements have a list of items to be considered when evaluating their levels of definition. These lists may be used as checklists. It should be noted, however, that some of these items may not be applicable for a given project.

- Refer to the Project Rating Information form in the questionnaire and locate the element. Discuss and determine how much about the element was known at the beginning of PS&E development. The participants should discuss and build consensus about how much the team knew about the issues pertaining to the element descriptions.
- Choose the appropriate (only one) definition level for the element (0, 1, 2, 3, 4, or 5) and check (√) the corresponding box in the Project Rating Information form. It should be brought to mind again that the time of determining the definition level is at the beginning of PS&E development. The descriptions of the definition levels are included in the questionnaire.
- Repeat the above steps for the subsequent elements in the APRA until all the elements have been assessed. Be sure to rate each element.

The assessment steps for an ongoing project are slightly different from those given above. Instead of recalling back to the beginning of the PS&E, the participants needed to use their current knowledge about the project, which has not been let yet.

This assessment process was very dynamic, and the research team had to make sure that the elements were assessed correctly by asking factual questions about what was known and what was not known about the element. Sometimes the participants had to consult others who might be more knowledgeable about the issues but could not attend the meeting, or they had to refer to some project documents as a reference for their discussions. The research team also had to avoid influencing the decision making of the participants on the definition levels of the elements. Notes on the discussions and facts of the projects were captured by the research team while the elements' scores were marked in the Project Rating Information sheet and keyed into the computer tool. At the end of the assessment, results were generated using the computer tool. Scores of all elements, categories, sections, and the project were presented. A list of highly risky elements was also generated and presented to the meeting participants. The research team presented the results to the participants to enhance their understanding of the APRA method. This was also the time for all the participants to discuss the project itself as well as the APRA method. A summary of the main points from these seven facilitated meetings are presented in Appendix 9.

The final part of the meeting was for the participants to provide feedback on the APRA method by filling out a one-page questionnaire. They were asked to provide their opinions on the following two propositions: 1) the APRA method helps identify critical risk elements that need to be managed during the project development process; and 2) the APRA method helps improve the advance planning process. They were also asked to provide any general comments and feedback they might have had.

Before closing the meeting, the team asked the participants about the possibility of providing more projects on which to test the APRA. If more projects were to be selected, the experts needed to do the assessment by their own since they were by then already familiar with the testing process.

Test Meeting Follow-up

After each meeting, the research team contacted the representative person in the district to obtain the project data that had not been provided prior to the test meeting. Complete project background data are essential for the later data analysis. Experience has shown that collecting project background data—especially on project cost, time and change—was much more challenging than had been expected since many times the data were not recorded properly or the persons who had been involved in the projects were no longer been working for the same district or even TxDOT itself.

The follow-up was also useful for assisting the district people who were trying to test the APRA on more projects after the test meeting. This effort resulted in having the APRA tested on six more projects by the experts on their own. Further information about the tested projects and test results will be presented in the following section.

4.4.3. Analysis of Test Data

Project Characteristics

At the end of the testing process, the APRA was tested on 17 projects, one of which was considered inappropriate for the test purposes since it was in the construction phase as mentioned above. The 16 projects left were numbered from 1 to 9 for eight completed projects and from 10 to 16 for seven ongoing projects. Of these 16 projects, one (project number 9) did not have sufficient basic background information and thus was eliminated from data analysis. As a result, there were 15 projects that underwent further data analysis, eight completed and seven ongoing.

Table 3 provides select characteristics of the completed projects. They were of five different types: interchange, new location freeway, new location non-freeway, widen freeway, and widen non-freeway. By the time the test was done, they had been complete for six years or less. The projects' final total installed costs ranged from more than $3.8 million to nearly $104.7 million with an average of about $20.6 million. This group of projects, though a limited number, represents a wide range of project types and sizes.

Table 3. Completed Projects Used for Testing APRA

ID	Project Type	Final Cost	Completion Date
1	Interchange	5,156,274	04/2003
2*	Interchange	7,444,231	10/2001
3	Interchange	4,710,195	04/2003
4	Widen Freeway	104,688,724	05/2006
5	New Location Non-Freeway	4,961,388	03/2006
6	Widen Non-Freeway	3,802,490	09/2004
7*	Widen Freeway and New Location Freeway	24,892,672	06/2006
8	Widen Non-Freeway	9,226,408	02/2006
	Minimum	3,802,490	
	Maximum	104,688,724	
	Average	20,610,298	

Notes: Projects denoted by "" had incomplete cost information*

Table 4 presents the basic information on the seven ongoing projects. These projects were of three different types: interchange, widen freeway, and widen non-freeway. The projects varied in terms of status, from preliminary design complete to PS&E (detailed design) complete. Their estimated total costs at the time of the test ranged from more than

$5.6 million to more than $97.1 million, with an average of about $38.8 million. Similar to the completed project group, this group also represents various types and sizes of projects.

Table 4. Ongoing Projects Used for Testing APRA

ID	Project Type	Status	Estimated Cost
10	Widen Freeway	PS&E Complete	97,145,536
11	Widen Non-Freeway	95% PS&E Complete	45,927,440
12	Widen Non-Freeway	Preliminary Design Complete	5,649,805
13	Interchange	70% PS&E	18,250,000
14	Interchange	PS&E Complete	19,162,594
15	Widen Freeway	90% PS&E Complete	10,425,213
16	Widen Non-Freeway	90% PS&E Complete	74,900,000
		Minimum	5,649,805
		Maximum	97,145,536
		Average	38,780,084

Analysis of Project Scores

As mentioned before, the elements' definition levels of the projects were recorded right at the meetings. The test results were presented to the meeting participants at the end of each meeting. For those projects for which the experts performed the test by themselves after a meeting with the research team, the experts keyed their decisions on the elements' definition levels into a blank Project Rating Information sheet and then sent it back to the research team. The research team would then key the definition levels into the computer tool to generate the test results, including scores of the elements, the 12 categories, the 3 sections, and the project as a whole.

After the calculations for all projects were complete, it was shown that project 12 had an overall score of 118 out of a 917 maximum possible score (equivalent to 12.9 percent), which was obtained when all elements had definition levels of 5. It should be noted again that if all elements had the definition levels of 1, the project's total score would be 70 points (or 7 percent); if all had definition levels of 2, the score would be 310 points out of 1000 points (or 31 percent). The project's score was almost perfect in practice, and most probably was unreasonable given that it was a project whose detailed design had not been started yet. The data on this project were considered unreliable, and thus the project was eliminated from project list for further analysis. As a result, there are eight completed and six ongoing projects left. It should be noted that with this number of projects qualified for analysis, statistical analysis cannot be used to the extent that it is meaningful with a large project sample.

Table 5 presents a summary of APRA scores for the completed projects and their sections. The first column on the left is the project identification number. The next three columns are the actual score, maximum possible score (when all elements had definition levels of 5), and percentage (the score divided by the maximum score) of the project as a whole. The maximum score represents 1000 less any elements that were deemed not applicable by the respondents. The next three groups of three columns are actual scores, maximum possible scores, and percentages of three sections in the APRA. The bottom three rows contain minimum value, maximum value, mean, and standard deviation of the corresponding columns.

Table 5. APRA Scores of Completed Projects and Their Sections

Completed Projects												
Project ID	**Project**			**Section I**			**Section II**			**Section III**		
	Score	**Max**	**%**	**Score**	**Max**	**%**	**Score**	**Max**	**%**	**Score**	**Max**	**%**
1	410	975	0.421	102	288	0.354	162	346	0.468	146	341	0.428
2	277	989	0.280	79	300	0.263	82	359	0.228	116	330	0.352
3	486	984	0.494	100	300	0.333	189	343	0.551	197	341	0.578
4	411	987	0.416	123	300	0.410	123	346	0.355	165	341	0.484
5	441	936	0.471	115	300	0.383	132	295	0.447	194	341	0.569
6	446	989	0.451	93	300	0.310	173	359	0.482	180	330	0.545
7	327	931	0.351	86	288	0.299	125	342	0.365	116	301	0.385
8	459	960	0.478	101	288	0.351	143	342	0.418	215	330	0.652
Min	277	931	0.280	79	288	0.263	82	295	0.228	116	301	0.352
Max	486	989	0.494	123	300	0.410	189	359	0.551	215	341	0.652
Mean	**407**	**969**	**0.420**	**100**	**296**	**0.338**	**141**	**342**	**0.415**	**166**	**332**	**0.499**
St. Dev.	71	24	0.072	14	6	0.047	34	20	0.098	37	14	0.104

The average and maximum scores of the completed projects are 407 and 969 points; the average percentage is 42 percent. To recap, the higher the score the less defined the project and thus the less desirable the result. This can be understood as, on average, at the beginning of PS&E (the time the experts used to determine the elements' definitions) the projects had 42.0 percent of their scope undefined. The most well defined project had a score of 277 out of 989 (28 percent) while the most poorly defined project had a score of 486 out of 984 (49.4 percent).

A closer look at the average percentages of sections I, II, and III shows that section I, Basis of Project Decision, tends to be more defined than section II, Basis of Design (33.8 percent of the scope undefined versus 41.5 percent.) In turn, section II tends to be more defined than section III, Execution Approach (41.5 percent versus 44.5 percent.) This result was expected since the sections were organized based on their relative sequence in the project development process. Issues that are the basis for project decisions should be better defined than issues that are the basis for design ones since a project can move to the design phase only after it was decided upon as a project. Likewise, a project is executed after it is designed, at least to some extent, thus the Execution Approach tends to be less defined than the Basis of Design.

APRA scores of ongoing projects and their sections are presented in Table 6. The most well defined project had an overall score of 240 out of a 923 possible score (equivalent to 26 percent of the scope still undefined) while the least well defined project had a score of 525 out of 988 maximum possible score (equivalent of a 53.1 percent undefined scope.) On average, the six ongoing projects had a score of 336 and a definition percentage of 36.4 percent. Similar to the completed projects, the ongoing projects tend to have section I as the best defined (30.3 percent undefined), followed by section II (34.5 percent undefined), with section III the least defined (44.5 percent undefined.) A likely reason for this is again that the elements were put in sections that are relatively in the same sequence as the project development process. The section with more elements performed earlier tends to be more defined.

Table 6. APRA Scores of Ongoing Projects and Their Sections

Ongoing Projects												
Project ID	**Project**			**Section I**			**Section II**			**Section III**		
	Score	**Max**	**%**	**Score**	**Max**	**%**	**Score**	**Max**	**%**	**Score**	**Max**	**%**
10	332	1000	0.332	106	300	0.353	105	359	0.292	121	341	0.355
11	283	1000	0.283	88	300	0.293	90	359	0.251	105	341	0.308
13	240	923	0.260	53	288	0.184	80	359	0.223	107	276	0.388
14	525	988	0.531	79	288	0.274	235	359	0.655	211	341	0.619
15	417	904	0.461	126	217	0.581	123	346	0.355	168	341	0.493
16	318	1000	0.318	39	300	0.130	105	359	0.292	174	341	0.510
Min	240	904	0.260	39	217	0.130	80	346	0.223	105	276	0.308
Max	525	1000	0.531	126	300	0.581	235	359	0.655	211	341	0.619
Mean	353	969	0.364	82	282	0.303	123	357	0.345	148	330	0.445
St. Dev.	103	44	0.108	32	32	0.158	57	5	0.158	43	27	0.116

It can be noted that the ongoing projects tended to be better defined than the completed projects (36.4 percent versus 42.0 percent undefined) even though most of the ongoing projects did not have PS&E completed as the completed projects did. Thus by the time the ongoing projects would have PS&E completed, they would be probably even better defined that they were. This fact may be due to the improvement in TxDOT's scope definition during project development. It could also be explained by the fact that when the experts assessed the completed projects' elements they had to recall the beginning of PS&E, which was in the past, and they might not have been able to remember all the facts that had been known then. In contrast, the ongoing projects' elements were assessed in real time, and the experts might have known better those things that were known and not known regarding each element. However, due to the limited number of sample projects, it is not possible to conclusively determine the significance of the differences between the two types of projects' scores.

Table 7 provides select basic score statistics of all the projects and their sections. As for all projects, the average APRA percentage is 39.6 percent. The best defined section is section I while the least defined section is section III.

Table 7. APRA Score Basic Statistics of All Projects and Their Sections

All Projects												
Project ID	Project			Section I			Section II			Section III		
	Score	Max	%	Score	Max	%	Score	Max	%	Score	Max	%
Min	240	904	0.260	39	217	0.130	80	295	0.223	105	276	0.308
Max	525	1000	0.531	126	300	0.581	235	359	0.655	215	341	0.652
Mean	384	969	0.396	92	290	0.323	133	348	0.385	158	331	0.476
St. Dev.	87	32	0.090	25	22	0.105	44	17	0.127	39	19	0.109

Analysis of Performance of Completed Projects

Analyzing project performance and its relationship with level of project scope definition would allow for better interpretation of the APRA scores of a project. This analysis will be effective only when a significant amount of projects have been tested using the APRA to generate project scores during project implementation. During the development of the APRA, a number of completed projects have been tested mainly to help facilitate understanding of how the APRA works in a project environment. The number of completed projects was not sufficient for a meaningful analysis of the relationship between project performance and APRA score. In this section, collected data on the completed projects' performance are presented and discussed to provide a closer look at the completed projects that were tested.

Data on four major aspects of project performance were collected for the completed projects; they are schedule, cost, change, and owner satisfaction. Schedule performance information is presented in Table 8. Durations were collected, including the initial estimates from the beginning of detailed design (PS&E) as well as actual durations for detailed design and construction. The difference between the estimated and actual durations was calculated and presented in terms of percentages. As shown in the table, there was one project that did not have detailed design and construction time information, one did not have detailed design time information, and one did not have construction time information. Three out of six projects that had complete detailed design information did have detailed design completed on time. No project had detailed design completed ahead of schedule, and the largest time escalation in schedule is 194.5 percent. Altogether the projects had an average of 34.8 percent detailed design time escalation. Summing up the estimated and actual durations of the projects' detailed design shows that the actual time was 3.5 percent higher than the estimated time. Similar to detailed design time, two projects had construction completed on time, while the highest time escalation was 60.8 percent, and no project had construction completed ahead of schedule. On average, the six projects with complete information had 16.2 percent of construction time increase while the increase of the sum of construction time was 12.8 percent.

Table 8. Completed Projects' Schedule Performance

Project	Detailed Design Time			Construction Time		
	Estimated (day)	Actual (day)	Δ (%)	Estimated (day)	Actual (day)	Δ (%)
1	578	608	5.2	518	547	5.6
2	N/A	N/A	N/A	N/A	N/A	N/A
3	2926	2926	0.0	373	373	0.0
4	2855	2855	0.0	1247	1247	0.0
5	38146	38146	0.0	591	650	10.0
6	N/A	N/A	N/A	365	587	60.8
7	1372	1495	9.0	N/A	N/A	N/A
8	752	2215	194.5	1070	1293	20.8
Overall	*46629*	*48245*	*3.5*	*4164*	*4697*	*12.8*
Average	*7772*	*8041*	*34.8*	*694*	*783*	*16.2*

The second performance indicator is cost. Table 9 presents the summary of the cost performance of the completed projects. Estimated and actual construction costs of all projects added up more than $93.4 million and $119.1 million, respectively, making the cost escalation amount to 27.5 percent. The lowest project cost escalation was three percent, while the highest was 363.7 percent. Averaging cost escalation percentages of all projects yields 87.0 percent. The estimated and actual total costs (detailed design, utility adjustment, R/W acquisition, and construction) of all eight projects were nearly $116.3 million and $164.9 million, respectively. The average cost escalation was 71.5 percent while the escalation of cost of all projects was 41.8 percent (when comparing estimated and actual costs of all projects).

Table 9. Completed Projects' Cost Performance

Project	All Costs			Construction Costs		
	Estimated ($)	Actual ($)	Δ (%)	Estimated ($)	Actual ($)	Δ (%)
1	4,924,910	5,156,274	4.7	4,153,410	4,532,809	9.1
2*	3,142,570	7,444,231	136.9	2,732,900	7,138,231	161.2
3	3,661,295	4,710,195	28.6	3,141,295	4,234,142	34.8
4	76,895,343	104,688,724	36.1	60,514,720	66,022,492	9.1
5	4,697,681	4,961,388	5.6	4,280,010	4,406,841	3.0
6	2,470,000	3,802,490	53.9	2,000,000	3,375,565	68.8
7*	17,970,000	24,892,672	38.5	15,000,000	22,000,000	46.7
8	2,512,000	9,226,408	267.3	1,600,000	7,419,437	363.7
Overall	116,273,799	164,882,382	41.8	93,422,335	119,129,517	27.5
Average	14,534,225	20,610,298	71.5	11,677,792	14,891,190	87.0
Notes: Projects denoted by "" had incomplete cost information*						

Another aspect of the study was change orders. On average, a project had 23 change orders with an average total cost of about $1.2 million, as displayed in Table 10. On average, a project had a change order value of 9.8 percent of estimated construction costs. In terms of percentage of estimated construction costs, the change order values had a wide range of values with 1.5 percent as the lowest and 47.3 percent as the highest.

The last performance indicator studied during the testing of the APRA is owner's satisfaction. The teams who tested the APRA on the projects were asked to provide their opinions on the success of each of the projects. They were asked to provide their evaluations on a scale from 1 to 10 (1 for a very unsuccessful project and 10 for a very successful project) based on the two following criteria:

- Based on the original plan/intent of the project set prior to the beginning of PS&E development, rate how the constructed project matches the original plan/intent.
- Reflecting on the overall project, rate how successful you feel the project has been.

Table 10. Completed Projects' Change Orders

Project	Change Order		
	Number	**Value ($)**	**Percentage of Estimated Construction Cost**
1	12	92,992	2.2%
2	11	107,892	3.9%
3	8	173,919	5.5%
4	70	8,066,539	13.3%
5	6	83,125	1.9%
6	7	30,685	1.5%
7	39	402,731	2.7%
8	31	756,696	47.3%
Overall	184	9,714,579	10.4%
Average	23	1,214,322	9.8%

As shown in Table 11, all projects were rated on the positive side of meeting project intent and overall success. On a scale from one to ten, the average project score for meeting project intent was eight while the average project overall success was 8.9. It can be inferred that in the APRA test participating teams' opinions, the projects were highly successful.

As discussed earlier, in all cases, according to the three objective project performance indicators (time, cost, and change), the projects had high time and cost escalation and a significant value of change orders and thus should probably not be considered successful if being evaluated based on those three criteria alone. However, the subjective project performance indicators (the APRA test teams' opinions) indicated that all the projects were successful. There must have been other factors beyond time, cost, and change orders that the participants took into consideration when evaluating the projects' success. Table 12 summarizes the completed projects' in terms of performance indicators and the APRA score.

Table 11. Owner's Satisfaction of Completed Projects

Project	Satisfaction	
	Meeting Project Intent	**Overall Project Success**
1	8	10
2	N/A	N/A
3	9	9
4	6	8
5	7	8
6	9	8
7	9	9
8	8	10
Average	8	8.9

Table 12. Summary of the Completed Projects' Performance and the APRA Score

Project	Overall APRA Score	Schedule Growth *(%)*	Cost Growth *(%)*	Change Order *(%)*	Perceived Success *(10-point scale)*
1	410	5.6	9.1	2.2	10
2	277	N/A	161.2	3.9	N/A
3	486	0.0	34.8	5.5	9
4	411	0.0	9.1	13.3	8
5	441	10.0	3.0	1.9	8
6	446	60.8	68.8	1.5	8
7	327	N/A	46.7	2.7	9
8	459	20.8	363.7	47.3	10

It should be noted, however, that with the small number of projects used for testing the APRA, no meaningful quantitative interpretation of the APRA score has been possible. For a more quantitatively intensive analysis of the relationships between the

APRA score and project performance indicators, more projects need to be scored using the APRA.

Experts' Evaluation of the APRA

The most important objectives of testing the APRA on real projects were to observe how the APRA works in real project environments and to obtain feedback from experts who participated in the testing process. In addition to the request to provide comments throughout the test, the participants were asked to give opinions on two specific propositions at the end of each test meeting: 1) The APRA method helps identify critical risk elements that need to be managed during the project development process, and 2) The APRA method helps improve the advance planning process. A Likert scale was used for both propositions. The experts could choose any level from 1 (strongly disagree) to 7 (strongly agree). Answers from the 32 experts are illustrated in Figures 16 and 17.

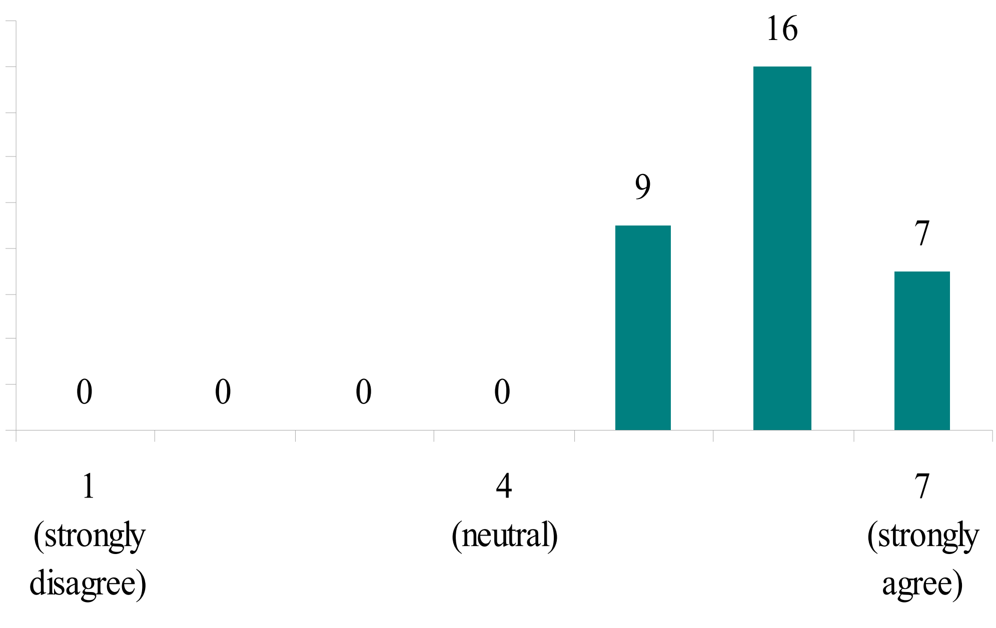


Figure 17. Expert Opinions on "APRA Helps Identify Critical Elements during PDP"

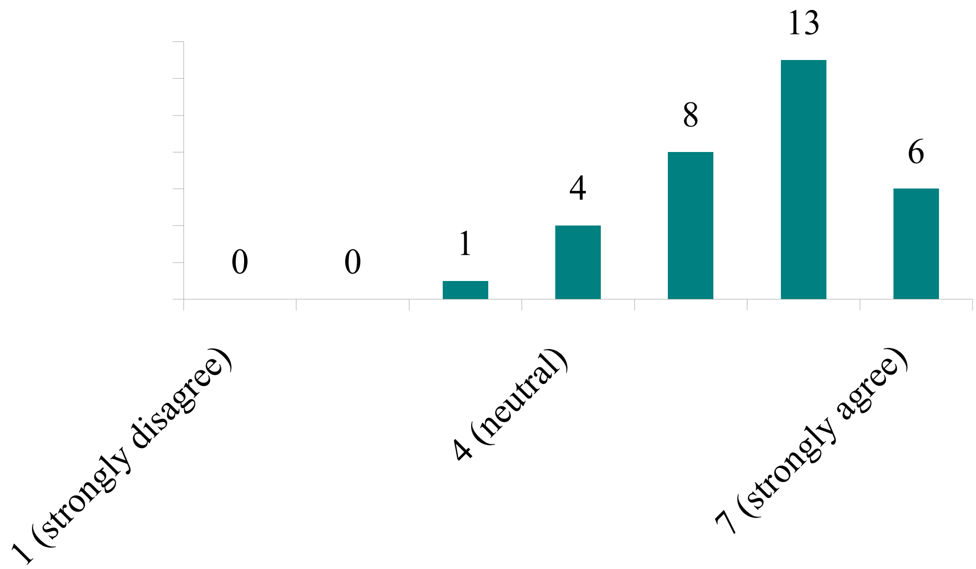


Figure 18. Expert Opinions on "APRA Helps Improve the Project Development Process"

As shown in Figure 17, all the participants agreed that the APRA method helps identify critical risk elements that need to be managed during the project development process. Its form as a checklist is the most obvious advantage of the APRA, and it could be very easy to use and helpful. The list of high risk elements that is identified at the end of each assessment also provided practical information to the project team.

The participants' opinions on the second proposition are presented in Figure 18. Most of the experts (27 out of 32) agreed that the APRA could help improve the advance planning process, four of them were neutral on the proposition, and one expert disagreed. This result shows great potential for the APRA to be brought into TxDOT's current process. Further discussions with the experts and analysis of their comments revealed the experts' insightful understanding of the method and the project development process. Some commented that the tool itself was good, but having it implemented could present certain difficulties since it could be seen as more work for the people who already felt overloaded. Top management would also need to support the implementation of the APRA since one of the biggest challenges in the project development process and in utilizing the APRA is getting people from different disciplines involved collaboratively.

These facts explain in part why there was some hesitation on the experts' agreement about the helpfulness of the APRA on improving the project development process.

Comments on the APRA

Besides quantifying the experts' evaluation of the APRA as explained in the previous section, the test also enabled getting direct comments from the experts. The experts' comments have demonstrated their insight into the APRA method, the issues it was trying to address, the helpfulness of the tool, and the potential obstacles in using it.

The comments are an illustration of their opinions on the two questions asked at the end of each test meeting and analyzed in the previous section. The comments represent diverse perspectives, and most of them were positive about the usefulness and benefits that the tool could offer.

Many of the experts had comments on how the APRA could help in identifying and managing risks during the project development process. And they agreed that properly managing risk was of great advantage for a project team; as an expert put it, "reducing risk would save time and money." Following are some of the comments that are pertinent to risk identification and management:

- "This is a great tool and reminder of items that need to be addressed during the project development process."
- "This should help speed up and identify issues early in the process. This will be a very beneficial program"
- "The APRA appears to be a useful tool for identifying critical elements of a project early in the planning stages. I feel this will be a tool that can be utilized by all of TxDOT's districts in the near future."
- "[The] APRA can give a very good overview of areas in a project that need attention."

One of the major advantages that the experts pointed out is that the APRA could help with improving communication among the project stakeholders. This awareness must have come from a good understanding of how important communication is for a project;

as an expert commented, "communication early is key for any project, large or small," or "[I] can see the need to have all parties involved earlier in project development." And after agreeing that the APRA would help with the project development process, an expert stated, "any tool that helps transferring communication from one section to the other is a benefit. The more we know about our processes the more we can work to perfect and correct them." However, according to one of the experts, "this process would require a team effort between engineering, environmental, right of way, and construction to be effective." Interestingly, this is exactly what the tool was developed to facilitate.

The experts also agreed that the APRA should be used at various points in time during project development to derive maximum benefits from it, especially since the APRA could help with monitoring project progress. The APRA "looks like a great tool. [It] should be used at various stages of a project," an expert noted. Commenting on the progress monitoring benefit and the helpfulness of the APRA to upper management, an expert stated, "this could be a good tool in assessing a project and monitoring the progress of a project. The risk assessment could help upper management to determine time requirements of the project and better understand delays based upon risks."

However, the advantages of using the APRA do not come unconditionally. Proper attention and support from top management and appropriate use of the APRA and the results it may provide must be present for the method to have its intended benefits. Take the interpretation of the APRA score of a project after an assessment meeting as an example: when a project has a high APRA score and a long list of high risk elements, it may indicate that the project has some areas that need more work, and concerned people should take actions accordingly while people from other disciplines should cooperate. If upper management took this opportunity to place blame upon the responsible people for letting the issues be poorly defined, or if people from other disciplines took this chance to point to others as where the "problems" are, it would not solve the problems but rather make the concerned people reluctant to use the APRA. One could also imagine that those who happened not to be in the spotlight this time would not be willing to use it in the future out of fear of being blamed for future problems. Thus, "for this tool to be effective, [the] administration has to support it. Also all who use it need to understand and practice it."

Not all comments were, however, positive. An expert commented, "I see utility in this program, but it seems to me that many projects will need to be evaluated before the full utility of the program is realized." It is correct that the use of the APRA would be better over time since the more projects on which the APRA is used, the more the user can make sense of the APRA scores. However, this current lack does not prevent a user from reaping the other benefits of using the APRA, such as helping identify critical risk elements or improving the involvement of project stakeholders, among others.

Another concern expressed about the use of the APRA is that "getting project managers and engineers to use the tools and implementing them will be difficult." This concern is understandable since people tend to resist change, especially when it seems that they will have more work to do and may feel overloaded already. However, investing more effort in better advance planning may result in better project performances as found out in the industrial and building construction sectors (CII 2008a, 2008b). It must be noted that every issue in the APRA will eventually have to be addressed. The APRA organizes and defines the effort, thus, hopefully leading to a more efficient planning process.

Given all the potential benefits pointed out, the APRA is just a method with a tool; it does not do anything itself, but rather helps the project team do its job better. The project team needs to build an action plan and act to solve problems, if any, based on the results from using the APRA. That is why the following comment was found to be very insightful: "I believe that the items are identified but it is still up to the individual manager to take these items and clarify and resolve these issues."

4.4.4. Benefits of the APRA

The APRA allows a project planning team to optimize the identification of the project requirements in all major disciplines (e.g., ROW, Utilities, Environmental, Design, and Planning and Programming) by quantifying, rating, and assessing the level of scope development. It is to be used mainly during the advance planning period and the project development process. A good feature of the APRA is that it can be utilized to fit the needs of different highway projects, large or small. Elements that are not applicable to a specific project can be zeroed in upon, thus allowing for their elimination from the final scoring calculation.

The APRA is a method and tool that may provide numerous benefits to owner organizations such as State Departments of Transportation as well as the highway construction industry as a whole. While further testing is needed for validation, the APRA may be used in the following ways:

- A checklist that a project team can use for determining the necessary steps to follow in defining the project scope. Using the APRA as a checklist has been well recognized and received by the APRA test meeting participants. In a period as short as two hours, a project team member can get to know the work progress of other functions while keeping the rest of the team updated on his or her function.
- A listing of standardized project scope definition terminology throughout the transportation construction industry. Standardized terminology can help improve communication among different project stakeholders, including professional consultants, the constructor, financiers, and the public.
- An industry standard for rating the completeness of the project scope development to facilitate risk analysis and prediction of escalation, potential for disputes, and so on. Knowing the status of each project development element would allow a project team to identify the sources of risk that can arise, analyze its probability and consequences, as well as develop an action plan.
- A means to monitor progress at various stages during the advance planning phase and the project development process. Using the APRA at different times in project development allows for tracking the progress of each APRA element and developing a proper action plan based on that progress.
- A tool to aid in communication and to promote alignment between owners (e.g. Texas Department of Transportation), design contractors, and other stakeholders by highlighting any poorly defined areas in the project scope. Using the APRA to

evaluate project development in a team setting allows for project team members to communicate about the issues within their functions to people of other disciplines and probably discuss strategies to tackle those issues. Open communication can help promote team alignment since team members know more about others' concerns and objectives.

- A means through which project team participants can reconcile differences using a common basis for project evaluation. Differences among the project team members can be better reconciled when the team has the chance to communicate openly. And project development assessment meetings using the APRA can provide an excellent basis as observed during the APRA testing process performed.
- A training tool for organizations and individuals throughout the industry. The APRA could serve as a starting point for TxDOT's new employees to familiarize themselves with the project development process, the tasks involved, the functions inherent to it, and the relative sequences of tasks.
- A benchmarking tool for organizations such as TxDOT to use in evaluating the completion of scope development versus the performance of past projects, both within their organizations and without, in order to predict the probability of the success of future projects. This use of the APRA will be enabled after it has been used for some time, a sufficient number of projects have been evaluated, and the evaluation and project performance data have been recorded for analysis.

4.5. Comparing Highway Projects with Building and Industrial Projects Using APRA and PDRI

As mentioned elsewhere, with such a small sample of projects tested using the APRA, there is a considerable limitation on the quantitative analysis of the APRA score and project performance. In order to provide a certain comparison among projects evaluated using the APRA and the PDRI (two versions), Table 13 was created to illustrate the performances of three groups of projects. The first group includes highway projects with an APRA score of greater than 200 points. The second groups consists of building projects with a PDRI (Building version) score of greater than 200 points. The third group includes industrial projects with a PDRI (Industrial version) score of greater than 200 points. It should be noted again that 200 is the cut-off point between well and poorly defined projects in building and industrial projects using the PDRI. There are three columns describing the performance of these three groups in terms of cost, schedule and change. As can be seen in the table, while the schedule and change performances of the highway group fall in between those of the two groups, its cost performance was much worse compared to those of the building and industrial groups (72% versus 9% and 4% over budget). Even though, the size of the highway group is very small (N = 8), the dramatically high cost overrun suggests that cost performance in highway projects might suffer the most from poor scope definition (as denoted by higher APRA scores) during the project development process.

Table 13. Comparing Groups of Projects Using APRA and PDRI

Group of Projects	Cost	Schedule	Change Orders
> 200 APRA points (N = 8)	72% over budget	16% behind schedule	10% of budget
> 200 PDRI Building points (N = 83)	9% over budget	21% behind schedule	11% of budget
> 200 PDRI Industrial points (N = 54)	4% over budget	10% behind schedule	8% of budget

4.6. Use of the APRA and Its Computer Tool

The APRA method has been developed and tested on real projects for its viability as a risk management tool that can help optimize the identification of requirements, including those of ROW, Utilities, Environmental, Design, and Programming during the projects development process. This section will be used to provide instructions about how to use the APRA method in practice. More details on how to implement the APRA can be found in a document called "TxDOT Best Practices Model and Implementation Guide for Advance Planning Risk Analysis for Transportation Projects" that the Center for Transportation Research has submitted to TxDOT (Caldas et al. 2007b). The approach in using the APRA and its computer tool was adopted from that of the PDRI by CII (2006a, 2006b) thanks to the similarity of the two methods and the proven success of the PDRI.

Individuals involved in the project development process should use the project score sheets shown in Appendix 6 and Appendix 8 when scoring a project. Note that two score sheets are provided—the first, as part of weighting workshop documents shown in Appendix 3, is simply an unweighted checklist. Appendix 6 contains the weighted values and allows the advance planning team to quantify the level of scope definition at any stage of the project on a 1000-point scale. The unweighted version should be used in the team scoring process to prevent bias in choosing the level of definition and in targeting a specific score. The team leader or facilitator can easily score the project during the weighting session using the score sheet in Appendix 6.

4.6.1. When to Use APRA

The APRA should be used at points throughout the project development process to ensure continued project alignment, process checkups, and a sustained focus on the key project priorities. Value can be gained by utilizing this tool at various points in the project development process, particularly in terms of progress tracking.

Project size, complexity, and duration will help determine the optimum times at which the APRA tool should be used. To aid in the expanded use of this tool, Figure 19 illustrates four potential application points where applying the APRA could be useful.

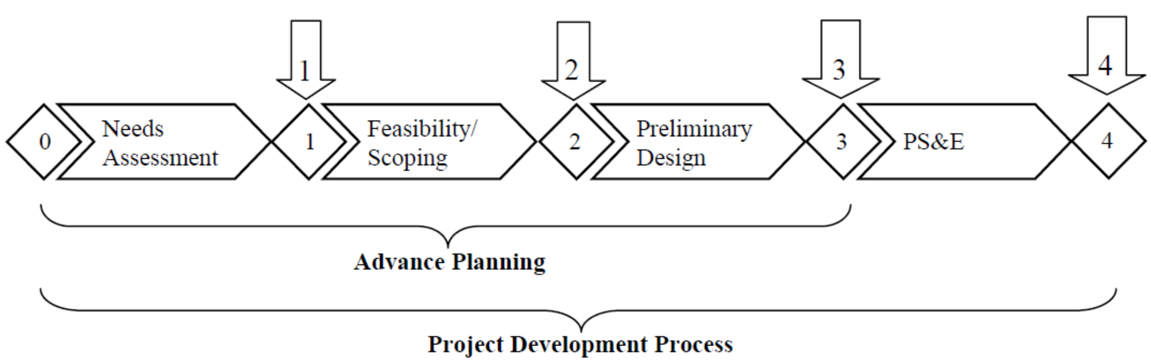


Figure 19. Employing the APRA, Application Points

Regardless of the timing of the APRA assessment, the same checklist/descriptions should be utilized and the evaluation should be conducted according to the following guidelines.

<u>APRA 1 Review</u>

This is a high level assessment of the project following Needs Assessment prior to Phase Gate 1, and it is part of the decision-making criteria for proceeding to the next phase. This assessment is typically held for projects at the Feasibility and Scoping Meetings, which bring decision makers, resource personnel, stakeholders, and technical personnel together for brain storming to identify alternatives for addressing the identified need. A Feasibility and Scoping Meeting is a corridor-oriented meeting in which broad issues related to purposes, needs, and alternatives are discussed. The APRA 1 Review should focus on the following areas:

- Aligning the team with project objectives;
- Ensuring good communication among the decision makers and the project development team; and,
- Highlighting stakeholder expectations to facilitate reasonable engineering estimates.

<u>APRA 2 Review</u>

This is a high level assessment of the project following the Feasibility/Scoping phase of the project prior to Phase Gate 2. This assessment is typically held at a Preliminary Design Conference (also known as a Project Concept Conference), which is a route-oriented meeting. At this gate more detail is known about the proposed project, and a feasibility study will already have been prepared. The purpose of this meeting is to bring together the project development team to identify the various alternate route locations. The APRA Section I, the Basis of Project Decision, should already be well-defined (with a low relative APRA score) at this phase gate. For small or simple projects, this assessment may not be necessary. In addition, the APRA 2 Review should focus on the following areas:

- Aligning project objectives and stakeholders' needs;

- Identifying high priority project deliverables that need to be completed;
- Helping to eliminate late-project surprises;
- Facilitating communication across the project development team and stakeholders.

The assessment will highlight the areas that resources need to be focused upon during the next phase of the project development process.

APRA 3 Review

This is typically the assessment of the project before proceeding to the Plans, Specifications, and Estimates development phase, which is initiated by a Design Conference (Phase Gate 3). The APRA 3 assessment should be conducted for all projects. At this stage, risk issues have been identified and mitigation plans have been put in place or are being developed.

APRA 4 Review

This is typically the final assessment of the project at the end of the Plans, Specifications, and Estimates development phase, prior to letting. The assessment can be done as part of a Final Design and Initial Construction Coordination meeting. At this assessment, all risk elements are thoroughly reviewed again by all stakeholders to make sure the project is ready to proceed to letting. All major issues should have been resolved by this point and any residual risk elements should be closely controlled.

In addition to the four APRA reviews outlined above, this tool can also be used at other points. For instance, it can be used early in the Needs Assessment phase as a checklist to help organize the work effort, or during the PS&E development phase (after Phase Gate 3) to monitor the progress of the PS&E development and to respond to any emerging issues during this phase.

As noted earlier, the APRA consists of three main sections that are broken down into 12 categories. The categories are further broken down into 59 elements. The elements are individually described in Appendix 2, Scope Elements and Their Descriptions. Elements should be rated numerically from zero to five. As indicated in the legend at the bottom of the score sheet, the scores range from one which equals complete definition, to five which equals incomplete or poor definition, with zero being reserved for Not Applicable. The elements that are as well-defined as possible should receive a perfect definition level of “one.” Elements that are not completely defined should receive a “two,” “three,” “four,” or “five,” depending on their levels of definition as determined by the team. Those elements deemed not applicable for the project under consideration should receive a “zero,” and thus they will not affect the final score.

An element should be assessed regarding its level of definition at a given point in time as defined in the section “Element Definition Levels.” For those elements that are completely defined, no further work is needed during the project development process. For those elements with minor deficiencies, no further work is needed during the project development process, and any ensuing issues will not impact cost and schedule performance at that stage; however, the minor issues identified will need to be tracked and addressed as the project proceeds, especially as the project progresses into the PS&E development phase. For those elements that are assessed as having some or major deficiencies, or are incomplete, further mitigation will need to be performed during the project development process prior to moving through Phase Gate 4. Most of the deficiencies must, however, be addressed prior to Phase Gate 3 if the project requirements are to be identified and managed effectively.

The relative level of definition of an APRA element is also tied to its importance to the project at hand. The flexibility of the APRA allows the project team some leeway in assessing individual element definitions. For instance, if the issues missing from the scope documentation of a particular APRA element are integral to project success (and reduction of risk), the team can rate the issue at a definition level of “three” or “four.” On a different project, the absence of definition of these same issues within an APRA element may not be of concern, and the team might decide to rate the element as a definition level “two.” As with any tool, practitioners should remain mindful of the specificities of their projects when using the APRA.

4.6.2. Assessing an APRA Element

To assess an element, one first needs to refer to the Project Assessment Sheet in Appendix 3 or Appendix 8 and then read its corresponding description in Appendix 2. Some elements contain a list of the items to be considered when evaluating their levels of definition. These lists may be used as checklists. All elements have six pre-assigned scores, one for each of the six possible levels of definition, again with zero denoting a non-applicable element.

Only one definition level (0, 1, 2, 3, 4, or 5) for each element should be chosen based on the perception of how well it has been addressed. The suggested method for making this determination is through open discussion among the project team members. One should ensure the understanding of the element issues by all participants and promote a common understanding of the work required to achieve complete definition. It is important to defer to the most knowledgeable team members (for example, on underground tank issues, defer to the assessment of the civil and environmental discipline leads), while respecting the concerns of the other team members. As the discussion unfolds, one should capture action items or potential gaps in the knowledge about an element. An example of an action item (gap) list is given in Figure 20.

Once the appropriate definition level for the element has been chosen, the value of the score that corresponds to the level of definition chosen should be written in the “Score” column. One should do this for each of the 59 elements in the Project Score Sheet. One should be sure to assess each element.

Each of the element scores within a category should be added up to produce a total score for that category. The scores for each of the categories within a section should then be added up to arrive at a section score. Finally, the three section scores should all be added up to achieve a total APRA score.

Project title/date:						
Item #	**APRA Element**	**Level of Definition**	**APRA Element Score**	**Item Description**	**Deadline/ Frequency**	**Responsible**
1	A3	4	23	Obtain and/or keep updated of funding sources data for construction; promptly report to the project manager and inform the project area offices when data become available	At least monthly	C. Smith
2	G2	4	14	Request and encourage frequent involvements of the construction consultants in providing input to the design	12/31/1995 and every 3 months	T. Campbell
3	G2	4	14	Perform constructability analysis for the design	12/31/1996	T. Campbell
4	H2	5	8	Develop equipment location drawings and distribute to the project area offices	6/31/1996	L. Nelson
5	K4	5	16	Develop a project schedule control plan with consideration of the availability of funding data and in consultation with the construction consultants; inform the project area offices	6/31/1996	R. Richardson
6	K6	4	10	Review and update the safety requirements and procedures; report to the project manager	12/31/1996	K. Jones
7	L5	5	13	Develop a preliminary traffic control plan	12/31/1996	R. Richardson

Figure 20. Example Action List

4.6.3. Philosophy of Use

Ideally, the project team should conduct an APRA evaluation at various points in the project. Experience has shown that the scoring process works best in a team environment with a neutral facilitator who is familiar with the process. The facilitator provides objective feedback to the team and controls the pace of the team meetings. See Appendix 10 for details about facilitation. If this arrangement is not possible, an alternate approach is to have key individuals evaluate the project separately, then evaluate it together, ultimately agreeing on a final evaluation. Even the use of the APRA from an individual standpoint provides a method for project evaluation, although group evaluation is preferable.

Experience has also shown that the APRA is best used as a tool to help project managers (project coordinators, project planners) organize and monitor the progress of the project development effort. In many cases, a planner may use the APRA prior to the existence of a team in order to gain insight into major risk areas. Using the APRA early in the project's life cycle will usually lead to high APRA scores. Such high scores are normal, and the completed score sheet gives a road map of the areas that are weak in terms of definition.

The APRA provides an excellent tool to use in early project team meetings in that it provides a means for the team to align itself with the project and to organize its work. The final APRA score is less important than the process used to arrive at that score. The APRA also can provide an effective means of handing off the project to other entities or helping to maintain continuity as new project participants are added to the project.

If the organization (e.g., a TxDOT district) has advance planning procedures and execution standards and deliverables in place, many APRA elements may be partially defined when the project advances to the advance planning phase. An organization may want to standardize many of the APRA elements to improve the cycle timing of planning activities.

The APRA scores may change on a day-to-day or week-to-week basis as team members realize that some elements are not as well-defined as initially assumed. It is important to assess such elements honestly. The planning process is inherently iterative, and any changes that occur in assumptions or planning parameters need to be resolved with earlier planning decisions. The target score may not be as important as the team's progress over time in resolving issues that harbor risk. To aid the team in understanding the APRA element scores, a guide to the interpretation of these scores was presented in the section "Interpretation of APRA Elements Scores."

The APRA was developed as a tool that captures elements at a specific point in time while keeping those elements as independent as possible. Most of the elements constitute deliverables in the planning process. However, a close review of the elements shows an imbedded logic. Certain elements must first be defined well in order for others to be defined.

Figure 21 outlines this logic at the section level. In general, Section I elements must be well-defined prior to defining Section II and III elements. Note that this is not a critical-path-method-type logic in that certain elements are completed prior to the point when the next elements can start. In many cases, elements can be pursued concurrently. As information is gained downstream, elements already defined have to then be revisited so that the activity of definition rating is recursive in nature.

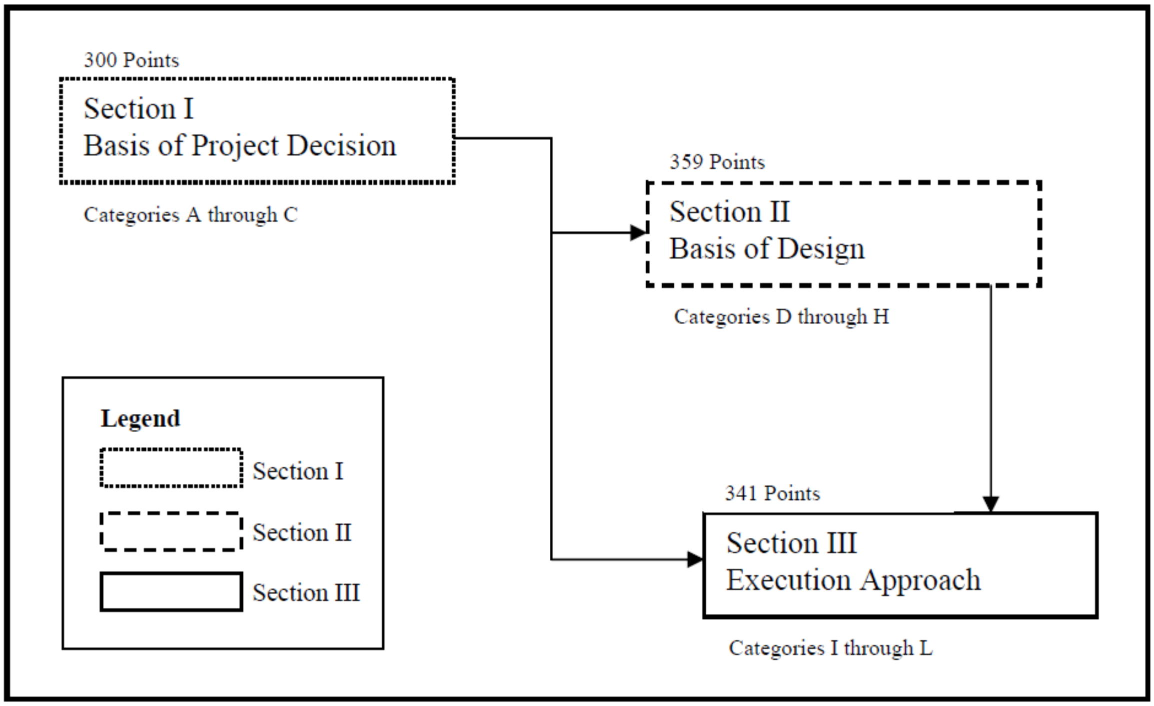


Figure 21. APRA Section Logic Flow Diagram

4.6.4. Use of APRA on Small or Renovation Projects

Small or renovation projects can also benefit from using the APRA, even if these projects are limited expenditures, short in duration, and frequently performed. Many large organizations such as the Texas Department of Transportation have a number of these projects ongoing at any given time. Projects of these types may be driven by environmental regulations or by the need to keep a facility in repair or merely in operation. Projects may also be focused on the restoration of a roadway or to facilitate relocation of a corridor.

On small or renovation projects, the requirements or scope may not encompass many of the elements contained in the entire APRA. In particular, some of the Basis of Project Decision elements found in Section I of the APRA may not be clearly defined or no R/W issues may be involved. Although business planning is generally performed on an owner's overall program of small projects, it may be difficult to determine if specific business decisions directly apply to one individual project. Customizing the APRA to reflect each individual project can be highly beneficial.

Normalizing the score

If an organization decides to create a scaled-down version of the APRA, it must be aware of the fact that this procedure will alter the maximum possible score from 1000 points to some lower number. Each time an element is deleted from the checklist, the maximum score for the project is reduced by that element's total weight. Furthermore, not only will the maximum score be reduced, but the lowest possible score that can be achieved with complete definition also will drop from 70 points to some lower number.

When using the APRA on smaller projects, the team must also determine a new target score at which its members feel comfortable authorizing a project for detailed design and construction. Through experience, each organization should develop an appropriate threshold range of scores for the particular phase of project development. This threshold is dependent upon the size, type, and complexity of the project.

For example, on a small 2-lane rural project, the APRA can be used effectively with some modification. Note that some elements may be assigned a value of zero as not applicable for this type of project (e.g., Bridge Structure Elements [F1], Equipment List [H1], Equipment Location Drawings [H2], and Equipment Utility Requirements [H3]). A "not applicable" element essentially presents no risk, meaning no potential negative impact to the project. Other elements may become more critical (e.g., Environmental Documentation [D5], Hydraulic Structures [F2]). After the assessment, if the organization's scaled-down version has a maximum possible score of 800 (after certain elements are given a not applicable [definition level 0] in the score sheet), it may determine that a score of 200 (25 percent of the total applicable points) must be reached before authorizing its small projects for PS&E development.

A word of caution should be given here. Using the APRA for these purposes should be done carefully or else elements that are more important for small projects may be given less emphasis than required. The operative phrase for using the APRA in these situations is common sense. An experienced facilitator can help in this regard.

4.6.5. Implementation across the Organization

The first requirement for implementation of the APRA across any organization (i.e., using it on all projects) is the unwavering support of upper management. Upper management should create a procedure that lists the utilization of the APRA as a requirement prior to authorizing a project to proceed with R/W release.

There is some danger in too much focus on scoring. Some smaller, maintenance projects may be fully acceptable at a much higher APRA score level as long as the project risks have been defined and a mitigation plan is in place to control the project. As stated before, common sense should prevail when reviewing the APRA results for a project. Requiring teams to reach a specific score could result in a team artificially adjusting the score so that the project can be executed to the possible detriment of the organization, project, and team participants. In most cases, it is more beneficial for the owner to have an APRA assessment along with identified risk issues (gap list) and corresponding mitigation steps. Managers should focus on the high risk elements generated in the assessment session, not just the APRA score. These are the issues that are of most concern as identified by the project team. Focusing too much emphasis on the score can lead to the use of the tool as an administrative exercise and not as an effective risk management approach.

The second requirement is a local champion. This person should be an enthusiastic supporter of the application of this tool. He or she should be in contact with other organizations using the APRA to gain knowledge of its use and foster the widespread application of the tool. This person should be an advocate of the benefits that this tool and method will bring to the organization.

The third requirement is training. A number of facilitators should be trained by the champion or an outside training resource. The number of facilitators will vary by organization and the number of projects that require approval. The objective of such training is to ensure that every project has access to a trained facilitator in a timely manner. The facilitator should NOT be a member of that project team. In many organizations, Project Managers are trained as facilitators for their peers' projects. In addition to a cadre of facilitators, all key members of the organization should be trained in how to participate in an APRA session and why their participation is important. In most cases, this is accomplished with just-in-time training. The trained facilitator will take the first 15 minutes or so of a session to brief the participants on the meeting's purpose and their role in making the session a success. Then the facilitator will take the opportunity to comment on specific helpful behaviors as team members progress through the assessment session. Soon all key members will be well-trained and know what to expect during an APRA assessment session.

If the APRA is implemented across an organization, its use should be monitored. The organization may wish to modify the APRA element descriptions to add discussion concerning proprietary concerns, lessons learned, or specific terminology based on its business environment.

4.6.6. Computer Tool Development and Instructions for Using

This section will provide an overview of the development of a computer tool for using the APRA method and the instructions for using this tool.

<u>Development of the Computer Tool</u>

In order for the use of the APRA method to be easy and effective a computer tool was needed. The computer tool was envisioned to be a tool that must satisfy the following requirements: 1) be user friendly, 2) help utilize the APRA method more effectively, 3) not require much training in use, and 4) not require more investment in software and hardware exceeding that of a normal office personal computer. With these parameters in mind, the research team decided to choose the Microsoft Excel program as the basis to develop the computer tool.

The first version of the computer tool was finished in April 2007. It was then presented to the TxDOT PMC members at a PMC meeting in Dallas in April 2007. The tool was well received by the PMC members at the meeting. A considerable amount of time was spent on discussing the tool, its functionality, and how to improve it. The tool was then revised based on the comments and feedback from the meeting while it was at the same time used for test meetings with districts from May to August 2007. The tool was finalized in August 2007. A screen shot of the APRA welcome screen is presented in Figure 22.

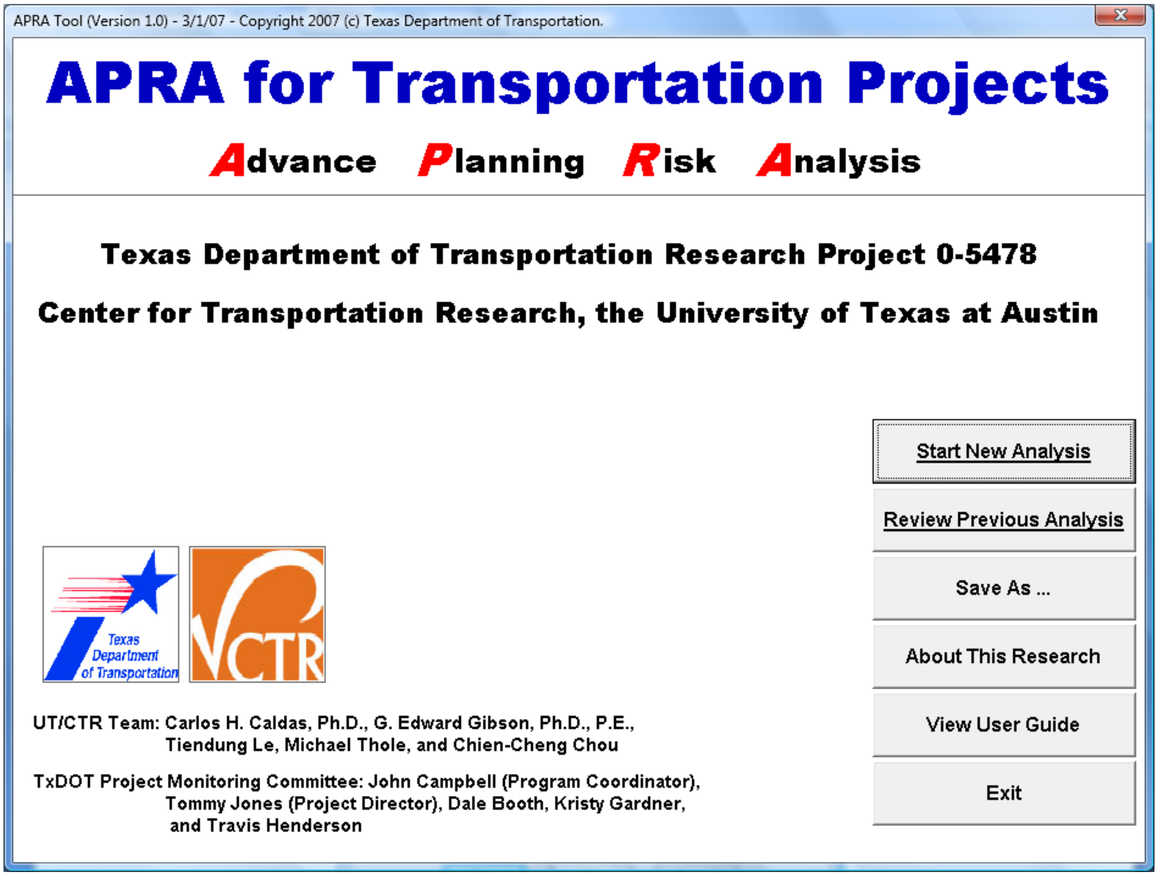


Figure 22. Welcome Screen of the APRA Computer Tool

Instructions for Using the Computer Tool

A user guide called "User Guide for the Advance Planning Risk Analysis Tool for Transportation Projects" (Caldas et al. 2007c) was developed to guide the users on how to use the computer tool. The user guide contains four chapters. Chapter 1 gives an overview of the APRA computer tool, including an introduction, system requirements, and the programming structure. Chapter 2 provides guidance about how to start using the computer tool including how to install it on a personal computer, how to start the program, and how to set up security. The major part of the user guide is the instructions for how to conduct a new analysis for a project. This part is reviewed in Chapter 3. In this part, the user is guided through each step of assessing a project, with intensive use of computer tool screen shots. There are six steps in conducting a new analysis, and these are as follows: 1) project information input, 2) assessment meeting input, 3) assessing elements in Section I, 4) assessing elements in Section II, 5) assessing elements in Section III, and 6) generating analysis summary and reports. The final part of the user guide, Chapter 4, gives instructions for reviewing a previous analysis of a project. This user guide is intended to be a companion document of the implementation guide that was discussed in the beginning of this chapter.

4.7. Conclusions on Development of APRA

Of the five phases of the project life cycle (Needs Assessment, Feasibility/Scoping, Preliminary Design, Detailed Design, and Construction,) the project development process covers the first four phases, with Advance Planning covering the first three. This process is a prime area for improvements in project delivery. Effective identification of project requirements during project development would help streamline the process and thus make the project available earlier for public benefit. The interdisciplinary nature of this process, however, makes this identification effort more challenging. Involvement of all disciplines during project development needs to be ensured if the overall identification effort is to be effective. Therefore, there was a need for a method that can help with accelerating this project requirements identification process across all functions of project development.

The Advance Planning Risk Analysis method was developed to meet this need. It is a method that, if used properly, can help facilitate the identification of project requirements during the project development process in all functions, including Planning and Programming, Preliminary Design, Environmental, ROW, Utilities, and Detailed Design. It is a method that can help the project development team control and manage critical project issues during project development. It can provide a platform for project participants to cooperate and coordinate project activities and responsibilities. It can help reconcile participants' difference through discussions. It can also be a means for training new personnel. And the APRA can be used to anticipate project performance after a certain period of time in use.

In the development of the APRA, a significant amount of literature was reviewed to ensure the comprehensive coverage of issues critical to project development regardless of project type and location. Intensive involvement of experienced TxDOT personnel in meetings, workshops, and interviews also helps to greatly improve the practicality of the method. A further step in making the APRA more helpful to the users is the development of a computer tool which is based on the Microsoft Excel software program. This tool makes the APRA easier to use and the results more easily exchanged.

The method and the tool were tested on real projects in order to gather comments and feedback from potential users. While more testing is required, the results are promising. The test results were highly positive because all of the 32 participating experts agreed on the usefulness of the method. Various forms of uses and benefits from the use were also observed and commented upon.

In short, the APRA method was developed to meet the need to optimize the identification of project development requirements. In its development, the researchers took into account a great deal of relevant literature and expert knowledge. The method was tested and well received by potential users, and its potential benefits were recognized. The following section will provide detail of the recommendations on the implementation of this method and research advancement.

CHAPTER 5. PHASE II - IDENTIFYING AND ANALYZING FACTORS AFFECTING RIGHT-OF-WAY SCHEDULE

Chapter 5 presents the process and results of the second phase of the research. The first section describes the investigation of the R/W acquisition process and identification of major milestones. The second section presents the identification of inherent factors that affect R/W acquisition schedule, followed by the data collection and checking process in the third section and the building of regression models for the total R/W acquisition duration in the fourth section. The fifth and sixth sections present the analysis of these factors' impacts on the R/W schedule and the results of qualitative data analysis. The last section draws conclusions on this phase of the research. Figure 23 illustrates the research process in this phase.

5.1. Right-of-Way Acquisition Schedule and Major Milestones

One of the first tasks of this research was to investigate the current R/W acquisition process in TxDOT's districts. The purpose was first to understand and then illustrate the acquisition process in the form of a flowchart, to identify major milestones during the process, and to obtain a subjective estimate of the acquisition timeline based on experts' opinions. In order to do that, the research team consulted a team of seven R/W experts from the Austin district of TxDOT. This expert team would serve as the advisory group to the research team throughout the research phase. The term "combined research team" will be used, hereafter, to refer to the combined group of the expert team and the research team. When no specific team is mentioned, the term "team" should be understood as denoting the combined research team.

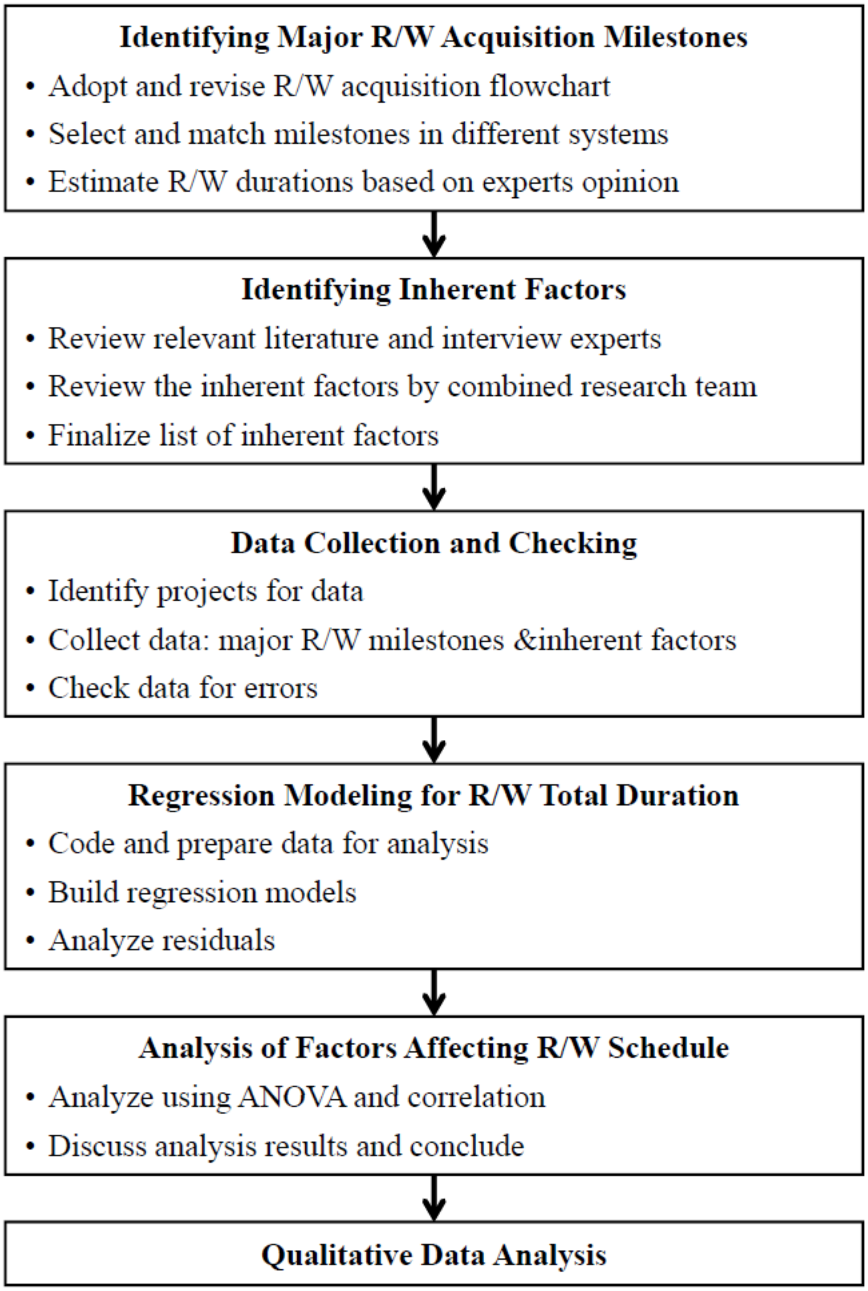


Figure 23. Detailed Research Flowchart Phase II: Identifying and Analyzing Factors Affecting R/W Schedule

The combined research team adopted TxDOT's then current R/W acquisition flowchart. A series of seven combined research team meetings were held from January to March 2008 to investigate and revise the acquisition flowchart. As a result, an updated

R/W Parcel Acquisition Flowchart was created. A portion of the flowchart is presented in Appendix 11. It includes 85 milestones for the entire process, ranging from early planning (e.g., Early Coordination with Local Agencies, Preliminary ROW/Utility Data Collection) to the end of relocation (Parcel Cleared for Utilities). However, to improve the legibility of the flowchart, a combination of milestones and activities were used to illustrate the process. The milestones and activities are presented in boxes and connected by arrows. For example, "Review/Approve Appraisal" is an activity, while "Present Offer" is a milestone. When only milestones are mentioned, it should be understood as either a milestone or the completion of an activity because the completion of an activity itself then becomes a milestone.

For further investigation of the acquisition process, the combined research team decided to select only the most critical milestones. As a result, 26 milestones were selected. Due to the terminological discrepancies, the flowchart milestones were matched with equivalent ones in Tracker, a database information system used by the Austin District to manage general, time, and cost data of the R/W acquisition process. This matching was crucial as the information system was one of two important sources of data (the other one is the Right-of-Way Information System used throughout TxDOT) that would be used in the research process.

A significant part of the meetings was spent estimating acquisition durations among 26 critical milestones. The objective was to estimate what a reasonable time for each of the durations should be. The estimates were expected to give the combined research team a sense of the R/W acquisition durations and provide one more reference source for later R/W acquisition schedule analysis and management. The idea is that under normal conditions (as defined by the assumptions), the estimates reveal the times in which a project team should be able to complete the work. These reasonable times were empirically estimated by the participating experts based on a number of assumptions, which are as follows:

- Time is based on calendar days.
- The project is in either an urban or suburban area.

- About 30 percent of R/W parcels, due to the owners' demands, have to be acquired using the eminent domain (condemnation) process.
- The economy is healthy.
- The appraisers are qualified.
- The title companies have work sophistication and are familiar with the TxDOT work process.
- Time is not of an essence.
- TxDOT is not in a budget crisis.
- There is a sufficient number of staff; staff is motivated.
- There are no mapping issues.

The list of the critical elements, their equivalents in other R/W information systems, as well as the experts' estimates of the durations are included in Table 14. As shown in the table, the duration from "R/W Release" to "Date of Deposit into Registry of Court" (for eminent domain parcels) was estimated at 387 days, while the duration from "R/W Release" to "Closing Date" (for parcels acquired by negotiation, a.k.a. deed) was estimated at 242 days. Appendix 12 provides a short description for each of these milestones to facilitate a common understanding and interpretation of them.

Table 14. R/W Acquisition Milestones

ROW Flowchart Milestone	Corresponding Tracker Event	**Estimated Duration** (since R/W Release)
Request Release	Right-of-Way Release	0
Receive Title Information	Title Commitment Received	90
Assign Appraiser	Appraisal Ordered	8
Review/Approve Appraiser	Approved by TxDOT	102
Present Offer	Offer Presented to Owner	107
Administrative Settlement Process (if requested)	Admin Settlement Initiated (Date of Owner Request)	152
Instrument of Conveyance Signed	Offer Accepted by Owner (Conveyance Date)	167
Possession and Use Agreement	Possession and Use (Date Paid)	N/A
Prepare Final Offer Letter	TxDOT Approval of Final Offer/Presented	157
Prepare and Submit Request for Eminent Domain	Parcel Sent to Condemnation (E-49 to Division)	164
Approve Updated Appraisal	Updated Appraisal Approved by TxDOT ROW Section	267
Minute Order Approved by Transportation Commission	Minute Order Issued	209
ROW Division Submits Parcel File to Attorney General	File Submitted to OAG	239
File Papers with Court	Law Suit (Petition) Filed	281
Special Commissioners Hearing	Date of Hearing	339
Judge Signs Award	Award Filed/Certified Copy Ordered	353
Objections Filed	Date Objections Filed	N/A
Request Warrant from Division	Warrant Requested	363

Table 14. R/W Acquisition Milestones (*Continued*)

ROW Flowchart Milestone	Corresponding Tracker Event	**Estimated Duration** (since R/W Release)
Judgment in Absence of Objections Procedure	Judgment in Absence of Objections Filed	N/A
Receive and Deposit Warrant	Date of Deposit into Registry of Court	387
Closing by Title Company	Closing Date	242
Send 30 Day Notice	30 Day Notice to Vacate Received	At Possession
Move Displacees	Actual Vacate Date	N/A
Asbestos Test of Structure	Asbestos Testing Ordered	30 (after Possession)
Removal of Improvements	Demolition Completed	N/A
Parcel Clear for Utilities	Parcel Clear	150 (after Possession)

5.2. Inherent Factors Affecting Right-of-Way Schedule

Identifying inherent factors that may affect the R/W acquisition schedule is essential in studying the R/W acquisition schedule for improvement. Again, inherent factors are defined as factors of the project and parcel that are relatively independent of the project team's direct influence and control. To start with, closely related literature was reviewed (e.g., Gibson et. al., 2006 and Heiner and Kockelman, 2005), and a preliminary list of factors was generated. A series of five interviews with seven R/W experts and project managers was conducted to solicit comments on each of the parcels about the issues that arose. While the main purpose of these interviews was to understand what went wrong in each of the parcels, the interviews provided good input toward identifying and confirming the inherent factors. The preliminary list of factors was updated based on the interview results. This updated list was then used as a starting point for discussions among the combined research team members at several meetings. Given their combined expertise in practice and research, the team was able to create a list of inherent factors with corresponding levels and units. The list was not considered final because there was still room for changing inherent factors as well as refining their levels during the data collection step, which will be explained in detail in the next section. While collecting data, the combined research team combined, and, in some cases, removed a number of factors. The levels of several qualitative factors were also revised to reflect better the project and parcel characteristics. Table 15 provides the final list of the factors, levels and units, and brief descriptions.

Table 15. Inherent Factors Affecting R/W Schedule and Their Levels, Units, and Descriptions

#	Factor and Level/Unit	Description
1	**Transitional Area:** • Rural • Urban • Suburban	"Transitional Area" describes the area that a parcel is located in (rural, urban, or suburban).
2	**Acquisition Method:** • By deed • By eminent domain (condemnation) • Eminent domain initiated but closed by deed	"Acquisition Method" describes how a parcel is acquired by the state, by negotiation (by deed) or by condemnation (by eminent domain). If the parcel is acquired by negotiation while the condemnation process is ongoing, the parcel's acquisition method is described as "eminent domain initiated by closed by deed."
3	**Ownership Type:** • Business • Individual • Multiple	"Ownership Type" describes how the parcel is owned, by a business entity, by an individual, or by more than one person.
4	**Use of Property:** • Residential • Business • Personal Property • Vacant	"Use of Property" describes the purposes of the use of the parcel, for residential purposes, for business purposes, as a personal property, or as a vacant property.
5	**Improvements:** • Yes • No	"Improvements" describes whether there is any improvement, such as a building, in the parcel.
6	**Bisection of Property:** • Yes • No	"Bisection of Property" describes whether the acquired parcel divides the owner's piece of land into more than one piece.
7	**Improvements Affected NOT in Acquired Area:** • Yes • No	"Improvements Affected NOT in Acquired Area" describes whether there is a decrease in value of any improvement on the owner's part of land (or that part of land itself) that is not to be acquired.

Table 15. Inherent Factors Affecting R/W Schedule and Their Levels, Units, and Descriptions *(Continued)*

#	Factor and Level/Unit	Description
8	**Title Issue:** • Yes • No	"Title Issue" describes whether there is any problems with the title of the land that may affect the acquisition. An example of a title issue is when there is still a lien on the property.
9	**Mapping/Survey Issue:** • Yes • No	"Mapping/Survey Issue" describes whether the parcel involves any issue with mapping or survey. An example is when the drawing of a parcel on the R/W map is incorrect and needs to be redrawn.
10	**Exchange Involved:** • Yes • No	"Exchange Involved" describes whether the parcel is acquired by exchanging a state-owned parcel of land for the parcel to be acquired from the land owner.
11	**Relocation (Displacement):** • Yes • No	"Relocation (Displacement)" describes whether the acquisition of the parcel involves relocating a business or residents who are living on the property.
12	**Demolition of Improvements:** • Yes • No	"Demolition of Improvements" describes whether the improvements on the parcel need to be demolished for construction purposes.
13	**Project's # of Parcels:** • Each	"Project's # of Parcels" describes the number of parcels that need to be acquired in the R/W project.
14	**Parcel Size:** • Acre	"Parcel Size" describes the area of the parcel in acre.
15	**Remainder Area:** • Acre	"Remainder Area" describes the area, in acre, of the owner's part of land that remains after the parcel is acquired.

5.3. Data Collection and Checking

With the critical R/W milestones identified and inherent factors identified and defined with levels and units, data collection was started by selecting R/W projects. Given the list of 26 milestones and 15 inherent factors, the data collection process was expected to be extensive and require great involvement of R/W experts who were involved in the projects. The projects should have been started in a relatively short period of time to improve the comparability among them as well as the accessibility and reliability of the data that would be collected. For these reasons, only those projects that were under the management of TxDOT's Austin district and started within five years from the data collection start date were considered. The TxDOT's Austin district expert team was asked to identify and recommend projects that met these criteria. As a result, 15 projects were selected for data collection purposes.

5.3.1. Data Collection for R/W Acquisition Milestones

The data collection started with R/W acquisition milestones. The combined research team utilized both electronic and physical sources to collect data. The main steps in collecting this type of data were the following:

1. Tracker. As an R/W data information management system used by the Austin district, Tracker was the starting point for the data collection efforts. Tracker included a comprehensive list of activities about the R/W acquisition process. However, R/W acquisition data had not been consistently entered into Tracker. Thus, the team was able to retrieve only about 30 percent of the needed data from it.
2. Project Managers' Individual Computer Files. Some project managers of the 15 projects maintained files to monitor select major milestones in R/W acquisition. With their help, the combined project team was able to collect more data on top of the 30 percent obtained from Tracker. In some cases, data in the computer files and Tracker did not match and triggered the need for double-checking the data. This double-checking helped improve the data's reliability.

3. Projects' Physical Files. Each project had a stack of physical files storing all documents, including correspondence among project participants and project R/W maps related to the projects. They are comprehensive sources of project data, but they require extensive efforts and a thorough understanding of the R/W process to locate and interpret relevant them. Fortunately, the projects' managers were all part of the TxDOT's expert team. The data collection was therefore much easier than it would have been otherwise. From April to November 2008, about 90 percent of the needed data was collected. The team decided to move on with data collection for the inherent factors and data checking, which will be discussed in the sub-section "Data Checking and Finalizing," while continuing to collect data that were still missing.
4. TxDOT's Right-of-Way Information System. The main reason that the ROWIS was not used at the beginning of the data collection is the difficulty in obtaining data from it. The ROWIS was a relatively slow web-based system. Moreover, the ROWIS did not contain data at the same level of detail as Tracker. And, only TxDOT personnel had access to it. However, the ROWIS was a helpful additional source of data that was employed when data could not be obtained from the other three sources and when data needed to be checked for accuracy.

At the end of the data collection process, one project was eliminated due to a significant lack of data for its two parcels. Another project was eliminated due to its special administrative arrangement. This project had been originally outsourced to another entity, which was to perform the entire R/W acquisition process. It was later changed to a semi-traditional project, whereby a consulting company would perform the R/W acquisition while all the approval and payment related activities would be performed by TxDOT. This special arrangement disqualified the project from the research, and the combined research team decided to exclude it. As a result, 13 projects were valid for further data collection and analysis. The data collected would then be checked and finalized, as will be discussed in the sub-section "Data Checking and Finalizing."

5.3.2. Data Collection for Inherent Factors

After the data collection for R/W acquisition milestones was substantially completed, data collection for the inherent factors of 13 projects was carried out from November to December 2008. Similar to those of the milestones, data for the inherent factors were collected using various methods and sources, including the following:

1. Projects' Physical Files. Most of the data for the inherent factors were stored in the projects' physical files only. Using the physical files, this part of the data collection was almost completed after multiple meetings with the project managers from November to December 2008.
2. TxDOT's Right-of-Way Information System. The ROWIS was used to collect data that could not be found during the meetings with the project managers using the project files. Together with the physical files, the ROWIS provided a complete data set for the 13 projects.

The data collected for inherent factors would then be checked and finalized, the details of which will be discussed below.

5.3.3. Data Checking and Finalizing

The processes of entering data into the information systems and collecting data from the physical files left much room for data inaccuracy, especially since the research required such extensive data collection efforts. The research team, therefore, strived to maximize the data reliability by carefully recording and checking data, taking the following specific steps:

- When manually recording data, the team carefully double-checked the data recorded whenever possible. This strategy effectively helped to minimize later checking efforts.
- The project managers were asked to examine the data collection sheets of their projects for possible errors. This strategy allowed for spotting any obvious errors in the data.

- Data for the inherent factors were examined for possible errors using the data for the milestones. For example, a parcel that has a “Deposit to the Registry of Court” date must be an eminent domain parcel, so if it was not so classified, it was reclassified. This somewhat simple strategy helped the team identify a number of errors in the data collected.
- The last, and probably the most formal, strategy used for checking the data collected was preliminary data analysis. Data for the R/W acquisition milestones were used to calculate durations among the major milestones. Basic descriptive statistics such as minimum, maximum, mean, and standard deviation were calculated. This preliminary data analysis was performed for all parcels as well as two distinct groups, eminent domain and negotiation groups of parcels. This strategy was very effective in identifying errors in the data collected by investigating negative durations and odd statistics.

The data checking strategies taken together helped the team identify and correct a considerable number of errors in the data collected. The reliability of the data was therefore greatly improved. This data checking process was completed by the end of December 2008. At that point in time, the data collected were considered final and ready for data analysis, which is the topic of the coming sections. Table 16 provides basic general information on the projects, parcels, and the inherent factors.

Table 16. General Information on Projects and Parcels

Characteristic (Unit)	Level/Statistic	Value
Number of Projects		13
Number of Parcels		172
Parcels per Project	Minimum	2
	Mean	13
	Maximum	42
Parcel Size (acre)	Minimum	.002
	Mean	.950
	Median	.284
	Maximum	41.055
Transitional Area (parcel)	Rural	57
	Urban	12
	Suburban	103
Acquisition Method (parcel)	Deed	99
	Eminent Domain	35
	ED started and closed by Deed	38
Ownership (parcel)	Business	78
	Individual	44
	Multiple	50
Use of Property (parcel)	Residential	3
	Business	12
	Personal property	10
	Vacant	147
Improvement (parcel)		14
Bisection of Property (parcel)		12
Improvements Affected NOT in Acquired Area (parcel)		8
Title issue (parcel)		10
Mapping/Survey Issue (parcel)		21
Exchange (parcel)		11
Relocation (parcel)		8

Table 16. General Information on Projects and Parcels (*Continued*)

Characteristic (Unit)	Level/Statistic	Value
Demolition of Improvements (parcel)		4
Percentage Taken (%)	Minimum	.03
	Mean	13.13
	Median	4.00
	Maximum	100.00

5.4. Regression Modeling of Right-of-Way Acquisition Total Duration

This section describes the model building process using regression for the R/W acquisition total duration (Total Duration), which is defined as from "R/W Release" date to "Possession." If a parcel is acquired by negotiation (deed), "Possession" is the "Closing" date; if acquired by eminent domain (condemnation), "Possession" is the "Deposit to the Registry of Court" date. The Total Duration is the dependent variable. Independent variables are the inherent factors identified.

5.4.1. Coding and Preparation of Variables for Model Building

All but three independent variables were qualitative and needed to be coded for data analysis. Each of the qualitative variables was coded using one dummy variable lesser than the number of levels of that qualitative variable. The "Reminder Area" was not used as an independent variable, but instead, "Percentage of Area Taken" was used to describe the percentage of the entire land area that was subject to acquisition. Table 17 presents the summary of variable coding results that were used for data analysis. The first column lists the inherent factors and the dependent variables; the second column presents the coded variables for the qualitative independent variables and variable names for the quantitative independent variables. The right column provides the values and units of the variables as well as comments when appropriate.

Table 17. Summary of Variable Coding Results

Factor/Dependent Variable	Coded Variable/Name	Value/Comment (Unit)
R/W Acquisition Total Duration	Total_Duration	Dependent variable (day)
Transitional Area	TA1_Sub	"1" if parcel is in suburban area; "0" otherwise
	TA2_Urb	"1" if parcel is in urban area; "0" otherwise
Acquisition Method	AC1_ED	"1" if parcel is acquired by eminent domain; "0" otherwise
	AC2_ED_Deed	"1" if eminent domain process started by eventually acquired by negotiation; "0" otherwise
Ownership Type	OW1_Indl	"1" if parcel is owned by individual; "0" otherwise
	OW2_Multpl	"1" if parcel is owned by more than one person; "0" otherwise
Use of Property	UP1_PP	"1" if there are personal properties without residents; "0" otherwise
	UP2_R	"1" if there is a residential property; "0" otherwise
	UP3_V	"1" if parcel is vacant; "0" otherwise
Improvements	Improvement	"1" if there are improvements; "0" otherwise
Bisection of Property	Bisection	"1" if there is a bisection of property; "0" otherwise
Improvements Affected NOT in Acquired Area	Not_Acquired_Affected	"1" if there are affected improvements that are not in acquired area; "0" otherwise
Title Issue	Title_Issue	"1" if there are title issues; "0" otherwise

Table 17. Summary of Variable Coding Results (*Continued*)

Factor/Dependent Variable	Coded Variable/Name	Value/Comment (Unit)
Mapping/Survey Issue	Mapping_Issue	“1” if there’re mapping issues; “0” otherwise
Exchange Involved	Exchange	“1” if parcel is exchanged; “0” otherwise
Relocation (Displacement)	Relocation	“1” if there’s relocation; “0” otherwise
Demolition of Improvements	Demolition	“1” if there’s demolition of improvements; “0” otherwise
Project’s Number of Parcels	Nmbr_of_Parcels	Number of parcels in the project
Parcel Size	Size	Size of the parcel (acre)
Percentage Taken	Percentage_Taken	Percentage of the acquired area compared to the entire land area (%)

5.4.2. Selection of Variables

Given the relatively large number of independent variables, it is effective to screen them to identify those that are significant in predicting the dependent variable to include in the regression models (Mendenhall and Sincich, 2003). A variation of the stepwise regression technique, backward elimination, was used to objectively screen the variables. All of the independent variables were first fed into a first-order linear regression model to find their Total Duration. Regression analysis was performed using SPSS Graduate Pack^{TM} 16.0 for Windows. The least significant variable was eliminated from the model, which was then run again. This process continued until there was no non-significant variable remaining. A significant level was defined at the p-value of 10 percent. As a result, nine variables were found significant in modeling the Total Duration. It should be noted that these nine variables represent only seven inherent factors because there are two factors that each used two significant dummy variables. The significant variables and their corresponding inherent factors are presented in Table 18.

Table 18. Significant Variables in Modeling Total Duration

#	**Significant Variable**	**Corresponding Inherent Factor**
1	TA1_Sub	Transitional Area
2	TA2_Urb	
3	AC1_ED	Acquisition Method
4	AC2_ED_Deed	
5	Title	Title Issue
6	Mapping	Mapping/Survey Issue
7	Exchange	Exchange Involved
8	Nmbr_of_Parcels	Project's Number of Parcels
9	Percentage_Taken	Percentage Taken

Apart from the objective variable screening method used, two subjective methods (using R^2 and adjusted R^2) were also utilized. During the screening using the objective method, R^2 and adjusted R^2 were calculated. The results in Figure 24 show that with 10 or more variables in the model, R^2 increases marginally while adjusted R^2 does not increase and even decreases in some cases compared to those of models with fewer variables. Therefore, nine variables in Table 18 were selected for further model building.

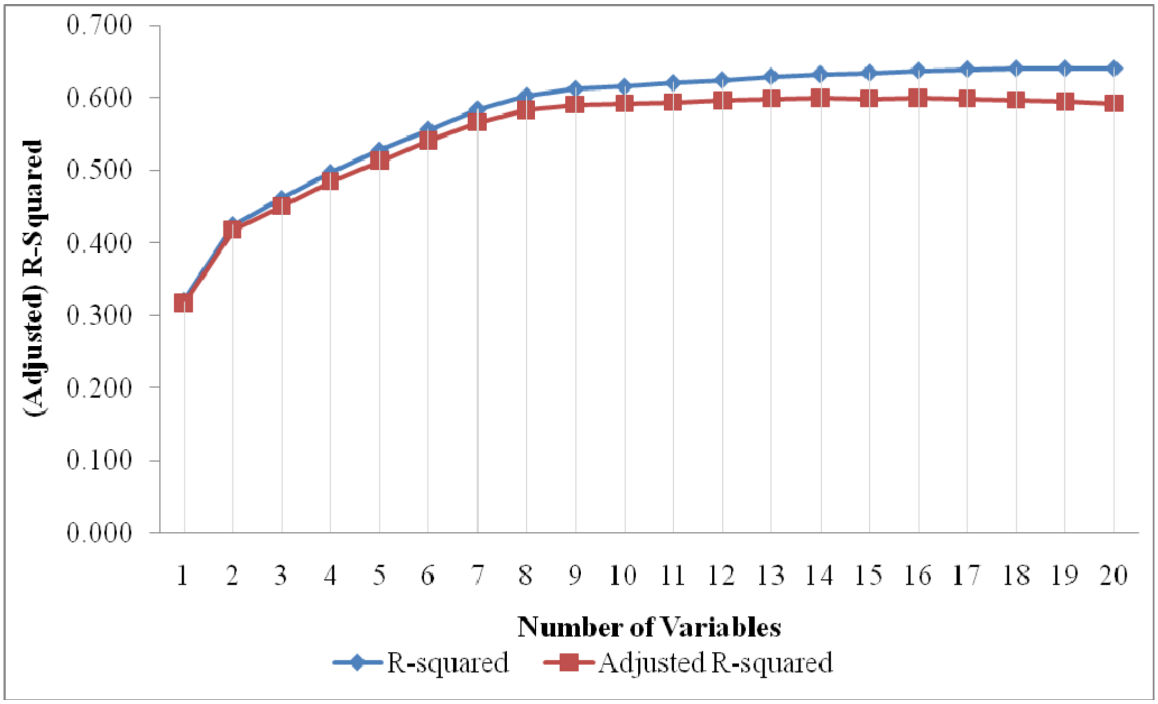


Figure 24. R^2 and adjusted R^2 against Number of Variables for Simple Linear Model

5.4.3. Model Building: First-Order and Log Transformation

As a starting point, a first-order regression model was built for Total Duration. The nine variables from the selection process were included in the model. Again, SPSS 16.0 was used to run the analysis. Table 19 presents a summary of the analysis results. As can be seen, the model is useful (global F value of 28.0) in predicting Total Duration, with an R^2 of 0.613. However, calculation showed that the Total Duration may be skewed by the value of 1.217. A histogram of the "Total_Duration" variable is shown in Figure 25. This value of skewness may affect the normality assumption of the residuals and may suggest that a natural logarithm transformation be a modeling candidate.

Table 19. First-Order Regression Model: Summary

Model Summary			
R	R Square	Adjusted R Square	Std. Error of the Estimate
.783	.613	.591	166.963

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	7026578.469	9	780730.941	28.007	.000
Residual	4432366.739	159	27876.520		
Total	1.146E7	168			

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	320.989	32.348		9.923	.000
TA1_Sub	-137.135	35.620	-.258	-3.850	.000
TA2_Urb	276.951	72.806	.262	3.804	.000
AC1_ED	236.657	35.861	.360	6.599	.000
AC2_ED_Deed	119.775	35.223	.192	3.400	.001
Title_Issue	162.049	58.186	.147	2.785	.006
Mapping_Issue	157.960	46.180	.200	3.421	.001
Exchange	459.143	73.858	.416	6.217	.000
Nmbr_of_Parcels	4.114	1.340	.210	3.070	.003
Percentage_Taken	-1.296	.618	-.107	-2.096	.038

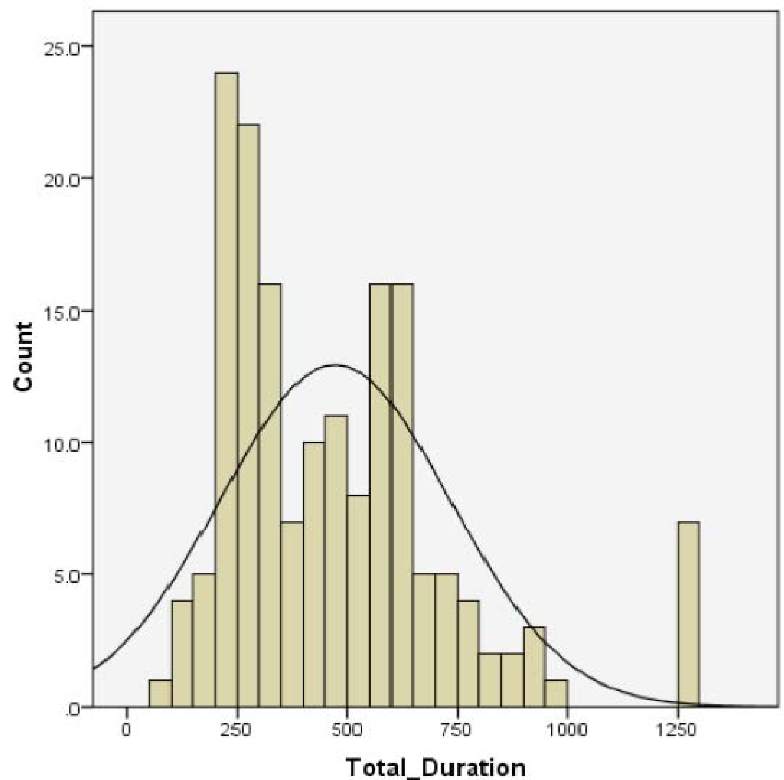


Figure 25. Histogram of “Total_Duration” Variable

A natural logarithm was used to transform the dependent variable. The new dependent variable was named “Log_Total_Duration.” A variable screening process that is similar to that of the simple linear model was used. The results show that there are nine significant variables in the regression model for Total Duration. Figure 26 also shows the relationships among the number of variables included in the model building and R^2 and adjusted R^2. Again, nine seems to be the optimal number of variables because beyond that, adjusted R^2 stops increasing and R^2 increases only marginally, if it does so at all. Table 20 presents a summary of the analysis results. The skewness of the Log_Total_Duration variable drops to 0.050, which is less likely to affect the normality of the residuals than the Total_Duration does. A histogram of the “Log_Total_Duration” variable is shown in Figure 27. However, the utility of the two models should be examined before selecting a model for further building steps.

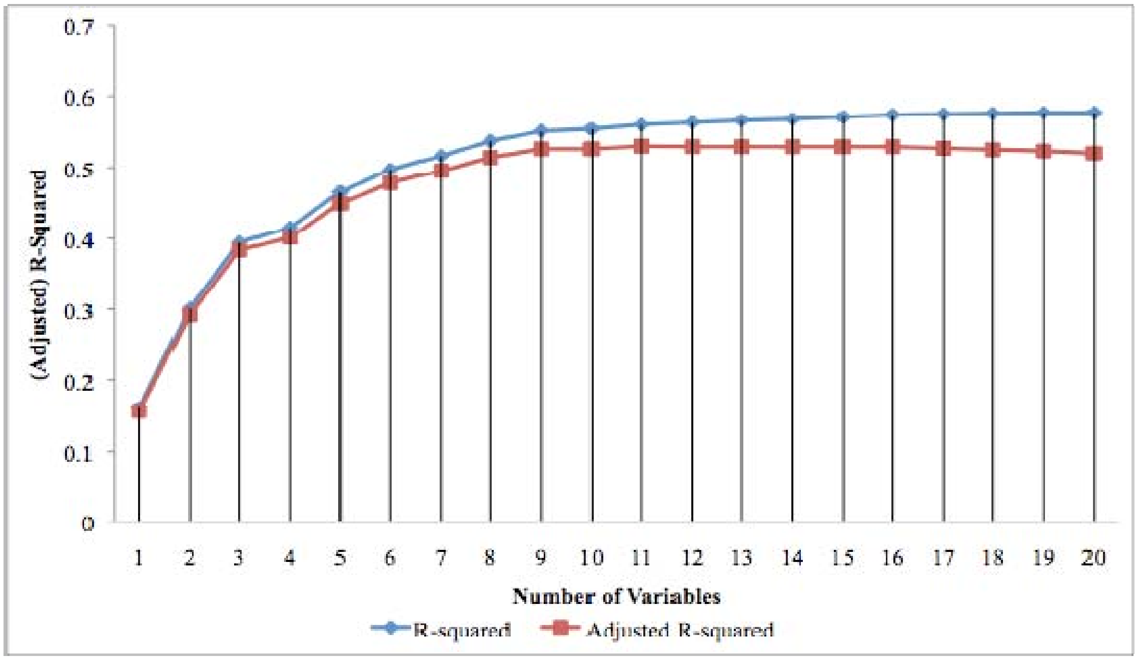


Figure 26. R^2 and adjusted R^2 against Number of Variables for Simple Logarithm Model

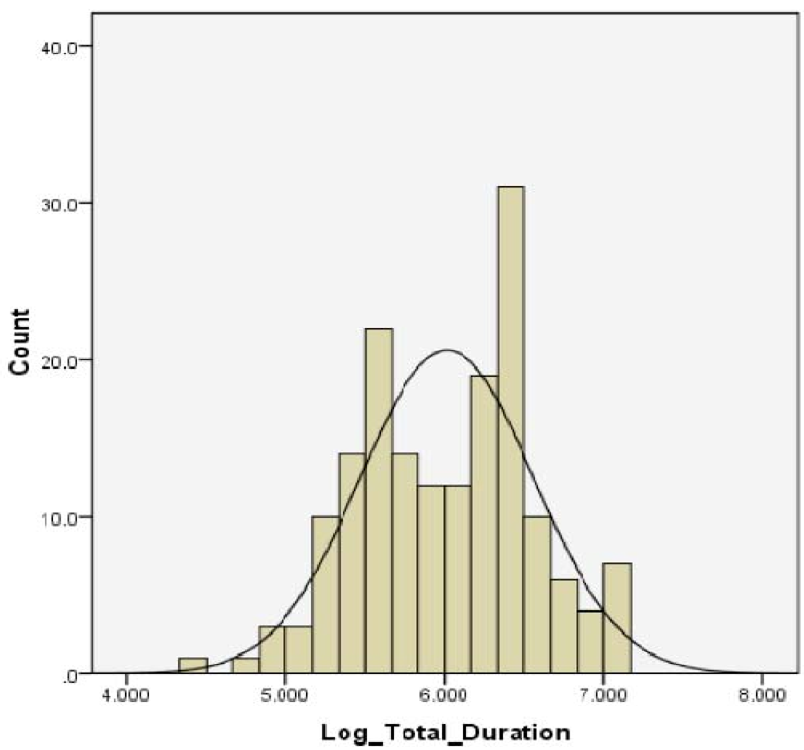


Figure 27. Histogram of "Log_Total_Duration" Variable

Table 20. Natural Logarithm Regression Model: Summary

Model Summary			
R	R Square	Adjusted R Square	Std. Error of the Estimate
0.743	.551	.526	.374880

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	27.473	9	3.053	21.721	0.000
Residual	22.345	159	.141		
Total	49.818	168			

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	5.676	.073		78.150	.000
TA1_Sub	-.393	.080	-.354	-4.914	.000
TA2_Urb	.413	.163	.188	2.528	.012
AC1_ED	.568	.081	.414	7.048	.000
AC2_ED_Deed	.285	.079	.219	3.599	.000
Title_Issue	.366	.131	.159	2.804	.006
Mapping_Issue	.392	.104	.238	3.781	.000
Exchange	.691	.166	.300	4.166	.000
Nmbr_of_Parcels	.012	.003	.294	3.989	.000
Percentage_Taken	-.003	.001	-.122	-2.227	.027

In order to compare the utility of the models, an equivalent R^2 (pseudo-R^2) needed to be calculated for the log model so that it could be compared to the R^2 of the simple linear model. First, using the model, the predicted value of the Log_Total_Duration for each set of the independent variables was calculated. The values of Log_Total_Duration were then inversely transformed to those of Total_Duration using the exponential function. The pseudo-R^2 was calculated using the following formula (Mendenhall and Sincich, 2003):

$$R^2_{\log(y)} = 1 - \frac{\sum (y_i - \hat{y}_i)^2}{\sum (y_i - \bar{y}_i)^2}$$

Where: y_i is the observed Total Duration value;

$\hat{y}_i$ is the inversely transformed Total Duration value;

$\bar{y}_i$ is the mean of the observed Total Duration values.

The calculation resulted in a pseudo-R^2 of 0.495. Therefore, from a predictive capability perspective, the untransformed model is superior to the logarithm-transformed model and therefore would be used for further model building.

5.4.4. Model Building: Interaction and Second-Order

Even though the first-order model was significant in predicting Total Duration, the next logical question was whether second-order and interaction terms computed from the nine independent variables would add significant value to the predictive capability of the model. First, all possible second-order and interaction terms from the nine variables were calculated. There were 34 interaction and nine second-order terms. Dummy variables of the same qualitative independent variable do not interact; in this case, they are TA1_Sub and TA2_Urb of "Transitional Area," and AC1_ED and AC2_ED_Deed of "Acquisition Method." The interaction and second-order terms needed to be screened for further model building. Each of the terms was added to the first-order regression model developed and the model was run again. If the term's coefficient was significant in the new model, the term would be kept for further model building. However, if the significant term had such a high collinearity with another variable that the software program automatically excluded the latter out of the model and the R^2 value did not improve, the significant term would not be included. As a result, fifteen interaction and one second-order terms were found to be significant and would considered in the next model building step. The list of the significant terms when individually added to the first-order model is presented in Table 21.

Table 21. Significant Interaction and Second-Order Terms When Individually Added to the Simple Regression Model

#	Term	#	Term
1	TA1_Sub*AC2_ED_Deed	9	AC2_ED_Deed*Exchange
2	TA1_Sub*Exchange	10	AC2_ED_Deed*Nmbr_of_Parcels
3	TA1_Sub*Nmbr_of_Parcels	11	Title*Mapping
4	TA2_Urb*AC1_ED	12	Title*Exchange
5	TA2_Urb*Exchange	13	Mapping*Exchange
6	TA2_Urb*Percentage_Taken	14	Mapping*Nmbr_of_Parcels
7	AC1_ED*Nmbr_of_Parcels	15	Exchange*Nmbr_of_Parcels
8	AC2_ED_Deed*Title	16	Nmbr_of_Parcels* Nmbr_of_Parcels

All of the 16 terms were added to the first-order model to make an all-inclusive second-order one. The backward elimination technique was used again to screen each of the insignificant terms out of the model. There were six first-order, four interaction, and one second-order terms that were significant and left in the model. The R^2 and adjusted R^2 are 0.819 and 0.807, respectively. However, a collinearity analysis revealed that the second-order term (Nmbr_of_Parcels*Nmbr_of_Parcels) had a dramatically high "Variance Inflation Factor" (VIF) of 88.6, which indicates a significant collinearity with one or more other variables. While high collinearity was expected for a model that involved a large number of variables including interactions and second-order terms, this exceptionally high VIF, especially when comparing to those of other terms, might not be desirable. The second-order term was therefore excluded from the model. The subsequent analysis resulted in a model with the highest VIF of 22.6, which was reasonably acceptable. This model has an R^2 of 0.815 and an adjusted R^2 of 0.803. The predictive capability of this model is much better than that of the first-order model. The test on the overall usefulness of the model has a global F statistic of 69.6, which is highly significant, indicating that the model contributes useful information for predicting Total Duration. Table 22 presents the results of the analysis with the coefficients of the model terms.

Because of the relatively small sample size and the relatively high R^2 of .0.815, it was not effective to consider other multiplicative models or to include more higher-order or more-than-two-way terms. The model building was, therefore, concluded with the second-order model, subject to the validation of the assumptions.

Table 22. Final Regression Model: Summary

Model Summary			
R	R Square	Adjusted R Square	Std. Error of the Estimate
0.903	.815	.803	115.837

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	9338864.951	10	933886.495	69.598	.000
Residual	2120080.256	158	13418.229		
Total	1.146E7	168			

Coefficients					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	384.403	28.608		13.437	.000
TA1_Sub	-368.930	49.124	-.693	-7.510	.000
AC1_ED	221.912	24.654	.338	9.001	.000
AC2_ED_Deed	303.314	46.835	.486	6.476	.000
Title_Issue	151.791	40.546	.138	3.744	.000
Mapping_Issue	959.964	124.739	1.216	7.696	.000
Nmbr_of_Parcels	-2.902	1.550	-.148	-1.872	.063
TA1xAC2	-219.428	54.225	-.326	-4.047	.000
TA1xNmbr	12.694	1.977	.867	6.422	.000
TA2xExchange	927.328	46.850	.710	19.794	.000
MappingxNmbr	-20.496	3.240	-1.028	-6.325	.000

5.4.5. Residual Analysis

Model estimated residuals were analyzed to check the model against the regression assumptions. First, the normal probability distribution assumption of the random error was checked using the normal P-P plot of regression standardized residuals as shown in Figure 28. The plot shows that the points lie reasonably close to the diagonal line. The normality assumption is therefore reasonably satisfied.

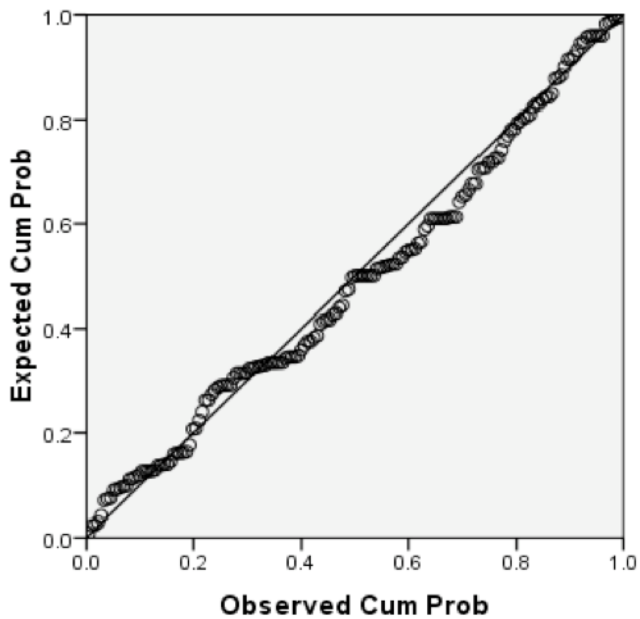


Figure 28. Normal P-P Plot of Regression Standardized Residual

A plot of residual against predicted value was used to check the zero mean, constant variance, and independence assumptions about the random error. The scatterplot in Figure 29 shows the distribution of the regression standardized residuals against the regression standardized predicted values. The figure shows that along the imaginative horizontal line at the residual of “zero,” the residuals tend to spread evenly on both sides and do not form a specific pattern. Therefore, there should be no significant concerns about the violation of the three assumptions. An unusual aspect of the plot may be that there are four points (corresponding to cases 122, 123, 124, and 125) that rest far to the right of the plot; these cases are of abnormally high values of Total Duration. However, the cases should not raise concerns about the violation of the assumptions as they lie almost exactly on the horizontal line at the residual level of “zero.”

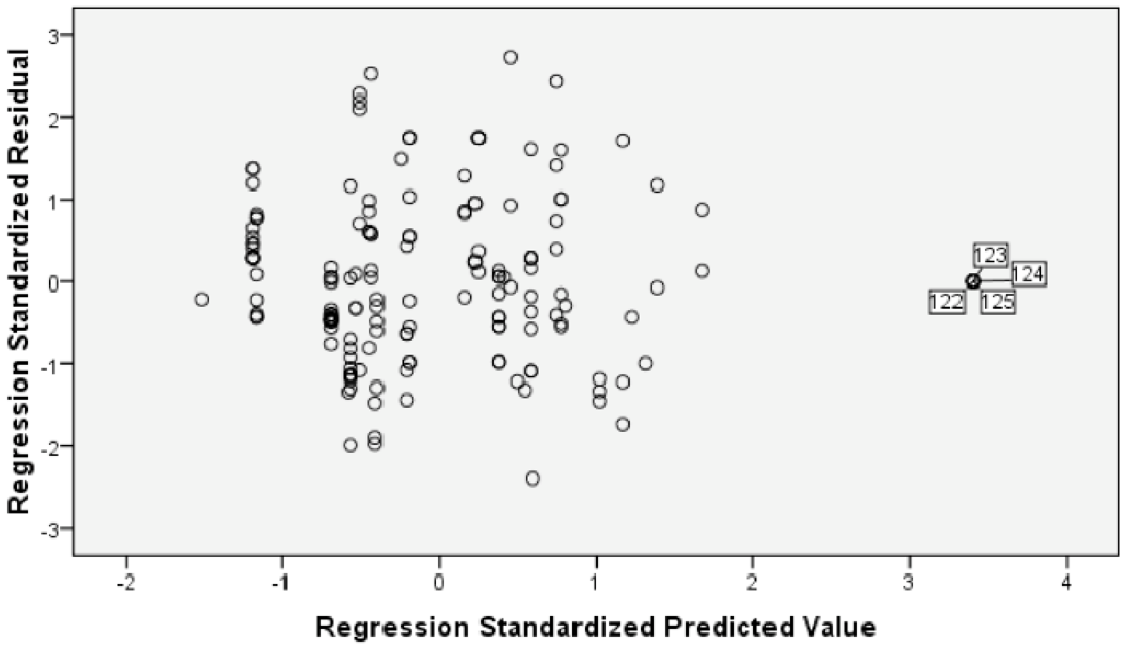


Figure 29. Scatterplot of Standardized Residual against Predicted Value

The scatterplot of the standardized residual can also be used to detect outliers. An observation is considered to be an outlier when the absolute value of its standardized residual is greater than 3 (Mendenhall and Sincich, 2003). The plot in Figure 29 shows that absolute values of all standardized residuals are smaller than 3. In fact, the residual statistics in Table 23 show that the standardized residual varies from -2.393 to +2.724.

Appendix 13 shows the actual and estimated (using the model) values of the Total Duration for each of the parcels. It also shows the residual of the model’s estimation. Even though the model developed shows high statistical significance, when compared to the practical requirements, it still needs a lot of improvements. This fact illustrates the challenges faced when solving the practical problems. It is therefore both necessary and beneficial to find different ways to improve the model. Alternatives include increasing the size of the sample and identifying and including more variables in the prediction model.

Table 23. Residual Statistics

Statistic	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	113.38	1274.00	472.30	235.772	169
Std. Predicted Value	-1.522	3.400	.000	1.000	169
Standard Error of Predicted Value	16.674	69.494	27.993	9.502	169
Residual	-277.255	315.509	.000	112.337	169
Std. Residual	-2.393	2.724	.000	.970	169
Stud. Residual	-2.631	2.901	.000	1.026	162

5.5. Analysis of Factors Affecting Right-of-Way Acquisition Schedule

A better understanding of the factors that affect the R/W acquisition schedule would be helpful to the project team in estimating and planning for the acquisition process. The helpfulness would be even greater if the project team would be informed of when in the acquisition schedule each of the factors might have a significant impact. This section provides the details and results of the analysis of the inherent factors' impact on the R/W acquisition total duration and its sub-durations. The details and results of the analysis of the relationships among the sub-durations as well as those between them and the total duration will also be presented. The analysis of variance (ANOVA) and correlation are the techniques that were used to perform the analysis, depending on the type of variable.

A preliminary examination of the data collected showed that the sample size was not sufficient to perform analysis on all sub-durations between all pairs of successive milestones. The main reason was that the majority of the parcels did not have data on many of the milestones because the parcels were acquired by negotiation and did not go through the condemnation process (and attending milestones). There were only 35 parcels (out of 172) that were acquired by condemnation. Therefore, the list of 26 milestones that was selected for data collection was again shortened to contain only 14 major milestones for further analysis. These milestones are the following:

- R/W Release
- Appraisal Ordered
- Approved by TxDOT
- Offer Presented to Owner
- Offer Accepted
- Closing
- TxDOT Approval of Final Offer / Presented
- Parcel Sent to Condemnation
- Minute Order Issued
- Law Suit (Petition) Filed
- Hearing
- Warrant Requested
- Date of Deposit into Registry of Court
- Actual Vacate Date

The fifth and sixth milestones (Offer Accepted and Closing) are applicable to negotiation parcels only. Negotiation parcels have only five sub-periods between five pairs of successive milestones. Condemnation parcels, on the other hand, have 12 milestones (all but the fifth and sixth). They include 11 sub-periods from 11 successive pairs of milestones. All parcels, negotiation or condemnation, share the same first three sub-periods because all parcels share the same path from the beginning to "Offer Presented to Owner." All 13 (11 + 5 - 3 = 13) sub-durations of the sub-periods were calculated and used for data analysis. ANOVA was used to analyze the effects of the first 12 inherent factors in Table 14 (represented by 12 categorical variables) on the 14 durations[2] (13 sub-durations and Total Duration). Correlation was used to analyze the relationships between each of the last three inherent factors (represented by three continuous variables) with the durations. The last variable, the remainder area, was

[2] "Duration" is used as a generic term to designate either a sub-duration or "Total Duration"

presented as "Percentage Taken," which equals the quotient of the parcel size divided by the total area. Correlation was also used to analyze the relationship among the durations. Table 24 presents selected descriptive statistics of the durations.

Table 24. Descriptive Statistics of R/W Acquisition Durations

Period	Duration	N	Minimum	Maximum	Mean	Std. Deviation
R/W Release *to* Possession	Total Duration	169	89	1274	472.3	261.2
Release *to* Appraisal Ordered	Sub-duration 1	163	2	442	61.4	54.4
Appraisal Ordered *to* Approved	Sub-duration 2	163	20	403	96.7	66.2
Approved *to* Offered	Sub-duration 3	163	1	946	25.1	81.0
Offered *to* Accepted	Sub-duration 4a	134	0	910	159.6	213.8
Accepted *to* Closing	Sub-duration 5a	127	10	602	117.1	95.0
Offered *to* Approval of Final Offer	Sub-duration 4b	82	1	337	87.3	80.9
Final Offer Approval *to* Condemnation Start	Sub-duration 5b	50	2	259	42.9	65.9
Condemnation Start *to* Minute Order	Sub-duration 6	61	5	221	36.2	26.2
Minute Ordered *to* Law Suit	Sub-duration 7	46	15	215	93.7	44.6
Law Suit *to* Hearing	Sub-duration 8	38	46	532	165.8	93.8
Hearing *to* Warrant	Sub-duration 9	32	6	287	38.9	51.3
Warrant *to* Deposit	Sub-duration 10	32	10	205	46.9	43.6
Possession *to* Actual Vacate	Sub-duration 11	102	0	439	56.8	69.0

Appendix 14 summarizes the results of the analyses of variance of the effects that 12 qualitative inherent factors (factored as categorical variables) have on the 14 durations. Post-hoc tests (Tukey) were also performed when significance was found for a factor that had more than two groups. Appendix 15 summarizes the results of the correlations among each of the three quantitative inherent factors and each of the durations.

5.5.1. Analysis Results and Discussions on Effects of Inherent Factors on R/W Durations

The effects of the inherent factors on the durations are reported and discussed as follows:

- **Transitional Area.** The analyses of variance revealed significant differences for Total Duration and five of the sub-durations, and these are as follows:
  - Total Duration, $F(2, 166) = 26.8$, $p < 0.001$; the post-hoc test revealed significant differences between urban and rural parcels and between urban and suburban parcels.
  - Sub-duration 1 (Release *to* Appraisal Ordered), $F(2, 160) = 3.8$, $p = 0.024$; the post-hoc test revealed significant difference between urban and suburban parcels.
  - Sub-duration 3 (Approved *to* Offered), $F(2, 160) = 5.4$, $p = 0.006$; the post-hoc test revealed significant differences between urban and rural parcels and between urban and suburban parcels.
  - Sub-duration 4a (Offered *to* Accepted), $F(2, 131) = 21.8$, $p < 0.001$; the post-hoc test revealed significant differences between urban and rural parcels and between urban and suburban parcels.
  - Sub-duration 5a (Accepted *to* Closing), $F(2, 129) = 7.4$, $p = 0.001$; the post-hoc test revealed significant differences between urban and rural parcels and between urban and suburban parcels.
  - Sub-duration 8 (Law Suit *to* Hearing), $F(2, 36) = 13.5$, $p < 0.001$; the post-hoc test revealed a significant difference between rural and suburban parcels.
- **Acquisition Method.** The analyses of variance revealed significant differences for Total Duration and four of the sub-durations, and these are as follows:

- Total Duration, $F(2, 166) = 8.1$, $p < 0.001$; the post-hoc test revealed a significant difference between deed (acquired by deed) and ED (acquired by eminent domain) parcels.
- Sub-duration 4a (Offered *to* Accepted), $F(1, 132) = 10.1$, $p = 0.002$; the post-hoc test revealed a significant difference between deed and ED then deed (eminent domain initiated but then acquired by deed) parcels.
- Sub-duration 5a (Accepted *to* Closing), $F(1, 130) = 8.5$, $p = 0.004$; the post-hoc test revealed a significant difference between deed and ED then deed parcels.
- Sub-duration 4b (Offered *to* Approval of Final Offer), $F(2, 83) = 4.2$, $p = 0.018$; the post-hoc test revealed significant differences between deed and ED parcels and between deed and ED then deed parcels.
- Sub-duration 11 (Possession *to* Actual Vacate), $F(2, 107) = 6.3$, $p = 0.003$; the post-hoc test revealed a significant difference between deed and ED parcels.

- **Ownership Type.** The analyses of variance revealed significant differences for Total Duration and three of the sub-durations, and these are as follows:
  - Total Duration, $F(2, 166) = 6.4$, $p = 0.002$; the post-hoc test revealed a significant difference between business (owned by a business) and multiple (owned by more than one individual) parcels.
  - Sub-duration 2 (Appraisal Ordered *to* Approved), $F(2, 166) = 6.5$, $p = 0.002$; the post-hoc test revealed a significant difference between business and multiple parcels.
  - Sub-duration 4a (Offered *to* Accepted), $F(2, 131) = 9.1$, $p < 0.001$; the post-hoc test revealed a significant difference between business and multiple parcels.

- Sub-duration 10 (Warrant *to* Deposit), $F(2, 30) = 4.8$, $p = 0.016$; the post-hoc test revealed a significant difference between business and individual (owned by only one individual) parcels.

- **Use of Property.** The analyses of variance did not reveal any significant difference for Total Duration and the sub-durations.

- **Improvements.** The analyses of variance revealed a significant difference for sub-duration 8 (Law Suit *to* Hearing), $F(1, 37) = 4.5$, $p = 0.041$.

- **Bisection of Property.** The analyses of variance revealed a significant difference for sub-duration 2 (Appraisal Ordered *to* Approved), $F(1, 161) = 6.7$, $p = 0.010$.

- **Improvements Affected not in Acquired Area.** The analyses of variance revealed significant differences for two of the sub-durations, and these are as follows:
    - Sub-duration 2 (Appraisal Ordered *to* Approved), $F(1, 161) = 12.4$, $p = 0.001$; and
    - Sub-duration 5a (Accepted *to* Closing), $F(1, 130) = 4.1$, $p = 0.046$.

- **Title Issue.** The analyses of variance revealed significant differences for Total Duration and three of the sub-durations, and these are as follows:
    - Total Duration, $F(1, 167) = 7.7$, $p = 0.006$;
    - Sub-duration 2 (Appraisal Ordered *to* Approved), $F(1, 161) = 5.3$, $p = 0.023$;
    - Sub-duration 5a (Accepted *to* Closing), $F(1, 130) = 16.2$, $p < 0.001$; and
    - Sub-duration 5b (Final Offer Approval *to* Condemnation Start), $F(1, 48) = 13.6$, $p = 0.001$.

- **Mapping/Survey Issue.** The analyses of variance revealed significant differences for Total Duration and three of the sub-durations, and these are as follows:
    - Total Duration, $F(1, 167) = 12.3$, $p = 0.001$;
    - Sub-duration 1 (Release *to* Appraisal Ordered), $F(1, 161) = 9.3$, $p = 0.003$;
    - Sub-duration 2 (Appraisal Ordered *to* Approved), $F(1, 161) = 6.9$, $p = 0.009$; and
    - Sub-duration 4a (Offered *to* Accepted), $F(1, 132) = 5.8$, $p = 0.017$.
- **Exchange.** The analyses of variance revealed significant differences for Total Duration and three of the sub-durations, and these are as follows:
    - Total Duration, $F(1, 167) = 78.5$, $p < 0.001$;
    - Sub-duration 3 (Approved *to* Offered), $F(1, 161) = 11.4$, $p = 0.001$;
    - Sub-duration 4a (Offered *to* Accepted), $F(1, 132) = 62.7$, $p < 0.001$; and
    - Sub-duration 5a (Accepted *to* Closing), $F(1, 130) = 8.0$, $p = 0.005$.
- **Relocation.** The analyses of variance revealed a significant difference for sub-duration 2 (Appraisal Ordered *to* Approved), $F(1, 161) = 6.6$, $p = 0.011$.
- **Demolition.** The analyses of variance did not reveal any significant difference for Total Duration and the sub-durations.
- **Number of Parcels.** The correlations revealed significant relationships between the number of parcels in the project and Total Duration and two sub-durations, as follows:
    - Total Duration, $r = +0.156$, $n = 169$, $p = 0.042$, two tails;
    - Sub-duration 1 (Release *to* Appraisal Ordered), $r = +0.230$, $n = 163$, $p = 0.003$, two tails; and

  - Sub-duration 2 (Appraisal Ordered *to* Approved), r = +0.219, n = 163, p = 0.005, two tails.

- **Size of Parcel.** The correlations revealed significant relationships between the size of the parcel and two sub-durations, and these are as follows:
  - Sub-duration 2 (Appraisal Ordered *to* Approved), r = +0.186, n = 163, p = 0.018, two tails; and
  - Sub-duration 5b (Final Offer Approval *to* Condemnation Start), r = +0.347, n = 50, p = 0.014, two tails.

- **Percentage Taken.** The correlations revealed a significant relationships between percentage taken of the original land and sub-durations 11, r = -0.228, n = 102, p = 0.021, two tails.

The analysis of the relationships between the inherent factors and the R/W durations has shown that six out of 15 factors had highly significant effects on Total Duration and at least three more of the sub-durations (all p values were smaller than 0.01). They are Transitional Area, Acquisition Method, Ownership Type, Title Issue, Mapping/Survey Issue, and Exchange. While other factors might have had a significant impact on some of the sub-durations, the six factors played a critical role in determining the R/W acquisition schedule. They therefore should be taken into consideration by the project team in planning for R/W acquisition. Taking Ownership Type as an example, the post-hoc test revealed that there was a significant difference between business ownership and multiple ownership in terms of their impact on the R/W acquisition schedule. This piece of information should be valuable for the project team with regard to different planning for projects with parcels owned by a business and or multiple people.

5.5.2. Analysis Results Discussions on Relationships among R/W Durations

This sub-section reports on and discusses significant relationships among Total Duration and sub-durations using correlation. These correlations are summarized in Appendix 16.

- **Total Duration.** The correlations revealed significant relationships among Total Duration and nine sub-durations, as follows:
  - Sub-duration 2 (Appraisal Ordered *to* Approved), r = +0.189, n = 161, p = 0.016, two tails;
  - Sub-duration 3 (Approved *to* Offered), r = +0.245, n = 161, p = 0.002, two tails;
  - Sub-duration 4a (Offered *to* Accepted), r = +0.821, n = 133, p < 0.001, two tails;
  - Sub-duration 4b (Offered *to* Approval of Final Offer), r = +0.246, n = 80, p = 0.028, two tails;
  - Sub-duration 5a (Accepted *to* Closing), r = +0.478, n = 127, p < 0.001, two tails;
  - Sub-duration 5b (Final Offer Approval *to* Condemnation Start), r = +0.324, n = 49, p = 0.023, two tails;
  - Sub-duration 7 (Minute Ordered *to* Law Suit), r = +0.556, n = 44, p < 0.001, two tails;
  - Sub-duration 8 (Law Suit *to* Hearing), r = +0.535, n = 37, p = 0.001, two tails; and
  - Sub-duration 10 (Warrant *to* Deposit), r = +0.527, n = 32, p = 0.002, two tails.
- **Sub-Duration 1 (Release *to* Appraisal Ordered).** The correlations revealed significant relationships between sub-duration 1 and two sub-durations, as follows:
  - Sub-duration 5a (Accepted *to* Closing), r = -0.188, n = 121, p = 0.038, two tails; and
  - Sub-duration 4b (Offered *to* Approval of Final Offer), r = -0.237, n = 76, p = 0.039, two tails.

- **Sub-Duration 2 (Appraisal Ordered *to* Approved).** The correlations revealed a significant relationship between sub-duration 2 and Total Duration, $r = +0.189$, $n = 161$, $p = 0.016$, two tails.
- **Sub-Duration 3 (Approved *to* Offered).** The correlations revealed significant relationships between sub-duration 3 and Total Duration and sub-duration 9, as follows:
  - Total Duration, $r = +0.245$, $n = 161$, $p = 0.002$, two tails; and
  - Sub-duration 9 (Hearing *to* Warrant), $r = +0.570$, $n = 28$, $p = 0.002$, two tails.
- **Sub-Duration 4a (Offered *to* Accepted).** The correlations revealed significant relationships among sub-duration 4a and Total Duration and four sub-durations, as follows:
  - Total Duration, $r = +0.821$, $n = 133$, $p < 0.001$, two tails;
  - Sub-duration 4b (Offered *to* Approval of Final Offer), $r = +0.526$, $n = 49$, $p < 0.001$, two tails;
  - Sub-duration 5b (Final Offer Approval *to* Condemnation Start), $r = +0.511$, $n = 23$, $p = 0.013$, two tails;
  - Sub-duration 7 (Minute Ordered *to* Law Suit), $r = +0.883$, $n = 11$, $p < 0.001$, two tails; and
  - Sub-duration 8 (Law Suit *to* Hearing), $r = +0.999$, $n = 4$, $p = 0.001$, two tails.
- **Sub-Duration 5a (Accepted *to* Closing).** The correlations revealed significant relationships among sub-duration 5a and Total Duration and three sub-durations, as follows:
  - Total Duration, $r = +0.478$, $n = 127$, $p < 0.001$, two tails;
  - Sub-duration 1 (Release *to* Appraisal Ordered), $r = -0.188$, $n = 121$, $p = 0.038$, two tails;

- Sub-duration 8 (Law Suit *to* Hearing), $r = +0.999$, $n = 4$, $p = 0.001$, two tails; and
- Sub-duration 11 (Possession *to* Actual Vacate), $r = +0.245$, $n = 78$, $p = 0.030$, two tails.

- **Sub-Duration 4b (Offered *to* Approval of Final Offer).** The correlations revealed significant relationships among sub-duration 4b and Total Duration and two sub-durations, as follows:
  - Total Duration, $r = +0.246$, $n = 80$, $p = 0.028$, two tails;
  - Sub-duration 1 (Release *to* Appraisal Ordered), $r = -0.237$, $n = 76$, $p = 0.039$, two tails; and
  - Sub-duration 4a (Offered *to* Accepted), $r = +0.526$, $n = 49$, $p < 0.001$, two tails.
- **Sub-Duration 5b (Final Offer Approval *to* Condemnation Start).** The correlations revealed significant relationships among sub-duration 5b and Total Duration and 2 sub-durations, as follows:
  - Total Duration, $r = +0.324$, $n = 49$, $p = 0.023$, two tails;
  - Sub-duration 4a (Offered *to* Accepted), $r = +0.511$, $n = 23$, $p = 0.013$, two tails; and
  - Sub-duration 6 (Condemnation Start *to* Minute Order), $r = +0.363$, $n = 44$, $p = 0.016$, two tails.
- **Sub-Duration 6 (Condemnation Start *to* Minute Order).** The correlations revealed a significant relationship among sub-duration 6 and sub-duration 5b (Final Offer Approval *to* Condemnation Start), $r = +0.363$, $n = 44$, $p = 0.016$, two tails.
- **Sub-Duration 7 (Minute Ordered *to* Law Suit).** The correlations revealed significant relationships among sub-duration 7 and Total Duration and sub-duration 4a, as follows:

- Total Duration, $r = +0.556$, $n = 44$, $p < 0.001$, two tails; and
- Sub-duration 4a (Offered *to* Accepted), $r = +0.883$, $n = 11$, $p = 0.006$, two tails.

- **Sub-Duration 8 (Law Suit *to* Hearing).** The correlations revealed significant relationships among sub-duration 8 and Total Duration and three sub-durations, as follows:
  - Total Duration, $r = +0.535$, $n = 37$, $p = 0.001$, two tails;
  - Sub-duration 4a (Offered *to* Accepted), $r = +0.999$, $n = 4$, $p = 0.001$, two tails;
  - Sub-duration 5a (Accepted *to* Closing), $r = +0.999$, $n = 4$, $p = 0.001$, two tails; and
  - Sub-duration 11 (Possession *to* Actual Vacate), $r = +0.245$, $n = 78$, $p = 0.030$, two tails.
- **Sub-Duration 9 (Hearing *to* Warrant).** The correlations revealed a significant relationship among sub-duration 9 and sub-duration 3 (Approved *to* Offered), $r = +0.570$, $n = 28$, $p = 0.002$, two tails.
- **Sub-Duration 10 (Warrant *to* Deposit).** The correlations revealed significant relationships between sub-duration 10 and Total Duration, $r = +0.527$, $n = 32$, $p = 0.002$, two tails.
- **Sub-Duration 11 (Possession *to* Actual Vacate).** The correlations revealed a significant relationship among sub-duration 11 and two sub-durations, as follows:
  - Sub-duration 5a (Accepted *to* Closing), $r = +0.245$, $n = 78$, $p = 0.030$, two tails; and
  - Sub-duration 8 (Law Suit *to* Hearing), $r = +0.557$, $n = 18$, $p = 0.016$, two tails.

The analysis showed that there were 20 significant relationships among Total Duration and the 13 sub-durations. Among those that had the most significant relationships with others are Total Duration, sub-duration 4a (Offered *to* Accepted), sub-duration 5a (Accepted *to* Closing), and sub-duration 8 (Law Suit *to* Hearing), each with nine, five, four, and four significant relationships, respectively. Especially, Total Duration had significant relationships with nine (out of 13) sub-durations. That may imply that much of the predictability of Total Duration is present early during the acquisition process. And in order to significantly reduce Total Duration, effort should be directed relatively evenly throughout the process; focusing on one or a few of the sub-durations may not return desirable results.

5.6. Qualitative Data Analysis and Descriptive Statistics for Major Sub-Durations

The R/W acquisition schedule involves a good number of sub-durations, each of which possesses unique characteristics, involves different stakeholders, and is affected in different ways. General qualitative information, such as potential issues, on each of the sub-durations based on historical data would be helpful to the R/W project team and the agents in action planning. General descriptive statistics on the sub-duration would also be helpful in providing a baseline from which the project team can monitor and assess the performance of the acquisition of a parcel and a project. Therefore, a tool has been developed to assist the project team in this regard. For each of the sub-durations, a summary sheet was developed using the qualitative data collected during the research course, select descriptive statistics, and results obtained from the quantitative data analyses.

Multiple sources were utilized to obtain qualitative data for the sub-durations, including the following:

- Literature review: while generating a preliminary list of inherent factors in R/W acquisition, a number of issues that might affect the R/W acquisition process in general and sub-durations (sub-periods) were identified. The inherent factors are in fact some of the issues.

- Combined research team meetings: although these meetings' main purpose was to identify the inherent factors affecting R/W acquisition schedule, the combined team also had rich discussions on the issues that might arise during the process.
- Expert interviews: five interviews with seven R/W experts and project managers on each of the parcels of the projects provided helpful input on the R/W acquisition sub-durations.
- Final expert reviews: after the qualitative data were collected and summarized, a list of potential issues that may arise and affect the R/W sub-durations was sent to R/W experts at the Austin district for review and comments. Input from the experts was then used to finalize the qualitative information section of the summary sheet.

Appendix 17 provides an example of the summary sheet of a sub-duration. The first section of the template provides basic descriptions on the two milestones of the sub-duration and a short explanation of the sub-duration. The next section summarizes basic descriptive statistics of the sub-duration, including minimum, maximum, mean, standard deviation, and expert estimate. And the last section, qualitative information, shows a brief list of issues that may arise during the two milestones along with select results from the quantitative data analyses.

5.7. Conclusions on Right-of-Way Schedule Study

This chapter presented in detail the entire process of the R/W schedule study in phase II. It started with reexamining the role of R/W in the project development process using the results from phase I. This reexamination led to the conclusion that R/W plays an important role in the PDP, and the need for an in depth study on R/W schedule was reaffirmed. Next was the study and adoption of an R/W schedule with major milestones was identified. These milestones would serve as the base for later analyses on the impacts of the inherent factors on the R/W acquisition schedule. The process of identifying the inherent factors was explained in detail. Data collection was a rigorous process whereby data were collected and checked for reliability. The data collected were then used for further analysis.

First, a regression model was developed for Total Duration, the period from R/W Release to Possession. The model built was highly significant (F = 69.6) with an R^2 of 0.815 and an adjusted R^2 of 0.803. It contains ten terms, including first-order terms and interaction terms. Second-order terms were considered but were not included in the final model. An analysis of the residuals confirmed that the model satisfied the assumptions underlying it. The model would be helpful for the project team to improve the capability of predicting the R/W acquisition duration. However, when compared to the practical requirements of prediction accuracy, the model should be improved. Increasing sample size and including more variables are two among the choices available for such improvements.

Starting with the conviction that understanding better the inherent factors would be helpful for the project team in planning for the acquisition of R/W, the next step was to use the data collected to analyze the impacts each of the inherent factors would have on Total Duration and each of the 13 sub-durations. The results suggested that six of the 15 factors had the most significant impact because they had significant effects on Total Duration and at least three other sub-durations. The analysis on the relationships among Total Duration and the sub-durations also showed that Total Duration had significant correlations with nine (out of 13) sub-durations. Three sub-durations had significant correlations with Total Duration and at least three other sub-durations. Therefore, more efforts should be invested in reducing Total Duration and the three sub-durations. All together, the study on R/W acquisition and the inherent factors resulted in positive findings that would be useful for the project team in predicting the R/W schedule and planning for the acquisition of parcels.

5.8. Comparing the Reviewed CTR's Study on R/W Acquisition and This Study

This section highlights several major differences between the study by the Center for Transportation Study and the second phase of this research.

The CTR study investigated the entire database on R/W acquisition maintained by the TxDOT (ROWIS) and then selected a sample of 45 projects each of which had at least 10 parcels. These 45 projects had 1620 parcels (an average of 36 parcels per project). In contrast, our research focuses on projects in the TxDOT's Austin district only. Thirteen projects with a total of 172 parcels were selected for comprehensive data analysis (an average of 13 parcels per project). Regarding the potential factors affecting the R/W acquisition schedule, the CTR's study considered a wide range of issues and grouped them into 9 categories. Our research takes into account only inherent factors. A significant difference between these two research is that the research by the CTR focused on the project level schedule (by studying critical path parcels) while our research studies the parcel level.

Another major difference between the two studies is the durations being investigated. The CTR studied three durations and our research investigates 12 durations. The CTR's study concluded that there were four major factors driving R/W acquisition. They are: 1) Total number of parcels, 2) Location type, 3) District R/W staff size, and 4) District annual R/W budget. Our study concludes that seven out of the 15 factors studied have significant impact on the R/W acquisition duration (from R/W Release to Possession). These significant factors are: 1) Transitional Area, 2) Acquisition Method, 3) Ownership Type, 4) Title Issue, 5) Mapping/Survey Issue, 6) Exchange, and 7) Number of Parcels.

Finally, the CTR's study found that the average duration from R/W Release to Possession of critical path parcels (of projects with ten or more parcels) was 1005 calendar days. That duration of the randomly selected parcels was 554 days. Our study found that the average duration is 442 days. Given the fact that projects in our research have an average of 13 parcels per project while those in the CTR's have an average of 36 parcels per project, these differences in the R/W acquisition duration seem to be consistent with the conclusions in both studies. The CTR's study concluded that "projects with fewer parcels tend to have quicker acquisition time" while our study found that "Number of Parcels" is a statistically significant factor that affects the R/W acquisition schedule. This similarity, to some extent, cross-validates the findings in both studies.

CHAPTER 6. RIGHT-OF-WAY ISSUES AND SCOPE DEFINITION: RELATIONS AND RECOMMENDATIONS

This chapter discusses, based on the analysis results of both study phases, the relations between R/W issues and project development scope definition and how the understanding of one can inform that of the other. It also offers recommendations for both practice and further research.

6.1. Right-of-Way in the Project Development Process

The development of the APRA has resulted in a list of weighted scope elements, which were not categorized by PDP function. In order to determine the role of R/W in PDP based on the APRA element weights, the elements need to be grouped by function. They can be grouped into the following six functions: planning and programming, preliminary design, environmental, R/W and utility, PS&E (plans, specifications, and estimates), and execution. Due to their nature of work process, R/W and utility are usually simultaneously mentioned in the APRA elements, and therefore they are grouped into one function. As can be seen in Table 25, R/W and utility function both have 13 APRA elements with a total score of 235, second only to preliminary design function. This finding reinforces not only the notion that R/W plays a crucial role in the success of the R/W acquisition process, but also the motivation to further study and improve the R/W acquisition schedule as well.

Table 25. APRA Elements Weights by Function

Function	Weight	Number of Elements
Planning & Programming	99	4
Preliminary Design	272	15
Environmental	94	5
R/W & Utility	**235**	**13**
PS&E	150	11
Execution	150	11
TOTAL	**1000**	**59**

Another approach to examining the role of R/W in the PDP is analyzing how the APRA R/W-related elements were defined in practice. Appendix 18 presents a summary of the test results of the 14 projects using the APRA. It shows the average level of definition and score of each of the elements, categories, and sections. Each element's level of definition and score is color coded based on its percentile rank, as follows:

- Red if the value is greater than the 95th percentile;
- Orange if the value is between the 75th and the 95th percentile;
- Yellow if the value is between the 50th and the 75th percentile;
- Light blue if the value is between the 25th and the 50th percentile;
- Blue if the value is between the 5th and the 25th percentile; and
- Green if the value is smaller than the 5th percentile.

A closer look at those elements with a level of definition greater than the 75th percentile shows that there are five (out of 13) R/W-related elements falling into this category (Table 26). These R/W-related elements are in the aforementioned shaded cells. This observation suggests that R/W-related issues tend to be less defined compared to other issues in the tested projects. Similarly, Table 27 shows that seven out of 14 elements that have an average score greater than the 75th percentile are R/W related issues. This implies that R/W related issues tend to cause high risk to the tested projects in comparison with issues in other functions. This fact might be explained by the fact that R/W related issues are important (evidenced by higher APRA weight) and at the same time tend to be less defined (evidenced by a higher average level of definition shown in Table 26 and Appendix 18). When these two factors are combined they make the R/W related issues to be more risky, as evidenced by the high average APRA score in Table 27.

It should be noted again that the average level of definition represents how well, on average, an element was defined in the tested projects; the average score, which is determined by both element's importance and level of definition, represents how risky, on average, an element was perceived to be in the tested projects.

Table 26. APRA Elements With Average Level of Definition of Greater than the 75th Percentile

#	Element	Level
43	I7. Procurement Procedures & Plans	3.8
13	C4. Determination of Utility Impacts	3.5
51	K4. Project Schedule Control	3.4
42	I6. Design/Construction Plan & Approach	3.4
58	L5. Preliminary Traffic Control Plan	3.4
40	I4. Utility Agreement & Joint-Use Contracts	3.2
35	H2. Equipment Location Drawings	3.2
37	I1. Long-Lead Parcel & Utility Adjustment Identification	3.1
59	L6. Substantial Completion Requirements	3.1
49	K2. Design & Construction Cost Estimate	3.1
32	G1. Provisional Maintenance Requirements	2.9
22	D8. Right-of-Way Mapping	2.9
33	G2. Constructability	2.8
50	K3. Project Cost Control	2.8
38	I2. Long-Lead/Critical Equipment & Materials Identification	2.8

Table 27. APRA Elements With Average Score of Greater than the 75th Percentile

#	Element	Score
13	C4. Determination of Utility Impacts	19.5
37	I1. Long-Lead Parcel & Utility Adjustment Identification	14.1
3	A3. Programming & Funding Data	13.0
49	K2. Design & Construction Cost Estimate	12.1
40	I4. Utility Agreement & Joint-Use Contracts	11.6
51	K4. Project Schedule Control	10.0
48	K1. Right-of-Way & Utilities Cost Estimates	9.7
24	D10. Right-of-Way Site Issues	9.1
42	I6. Design/Construction Plan & Approach	9.0
33	G2. Constructability	8.9
12	C3. Survey of Existing Environmental Conditions	8.7
39	I3. Local Public Agencies Utilities Contracts & Agreements	8.2
22	D8. Right-of-Way Mapping	8.1
50	K3. Project Cost Control	8.1

While five of the 13 R/W-related elements are in the top quartile by level of definition criterion, ten of them are in the top half, or two top quartiles. When it comes to comparisons in terms of levels of risk (i.e. APRA score), seven out of 14 elements in the top quartile are R/W related. An ANOVA revealed that the R/W-related elements are rated significantly differently from other elements in terms of levels of definition (at 90 percent confidence) and APRA scores (at 95 percent confidence). Detailed statistical analysis results are shown in Figure 30. These analysis results not only confirms the importance of studying R/W issues, but also suggests that R/W-related issues are significant sources of risk in the project development process.

		Sum of Squares	df	Mean Square	F	Sig.
Level	Between Groups	1.180	1	1.180	3.140	.082
	Within Groups	21.410	57	.376		
	Total	22.589	58			
Score	Between Groups	71.339	1	71.339	8.306	.006
	Within Groups	489.567	57	8.589		
	Total	560.906	58			

Figure 30. ANOVA Results for R/W-Related Elements' Level of Definition and APRA Score

6.2. Right-of-Way Inherent Factors in the Advance Planning Risk Analysis

As presented in Chapter 5, there are seven R/W inherent factors that had a significant impact on the R/W acquisition duration. Six of these seven factors are addressed in the descriptions of the APRA elements. In many cases, the factors are mentioned in more than one element. For example, "Ownership Type" is mentioned in elements D6 (Property Descriptions) and D7 (Ownership Determinations); and "Mapping/Survey Issues" is addressed in elements C3 (Survey of Existing Environmental Conditions), D3 (Surveys and Planimetrics), D8 (Right-of-Way Mapping), D9 (Constraints Mapping), and E3 (Schematic Layouts). Only one factor, "Exchange," was not mentioned in the APRA elements' descriptions. The exclusion of this single factor suggests that the APRA may need to be updated in the future to capture the potential issues as comprehensively as possible. However, at this point in time, the APRA elements are believed to be adequately addressing R/W and other issues in the PDP. The seven inherent factors that have a significant impact on the R/W acquisition duration are listed below along with the corresponding APRA elements that address them:

- Transitional (urban, rural, or suburban): elements B4 and C1;
- Acquisition method (negotiation or condemnation): element D8;

- Ownership type (business, single owner, or multiple owner): elements D6 and D7;
- Title issue: elements D10 and I1;
- Mapping/survey issue: C3, D3, D8, D9, E3;
- Exchange (the parcel is exchanged or not): no element; and
- Number of parcels (in the project): element D10.

While some of the factors occurred in multiple elements, some were not encountered at all. Five of the seven significant inherent factors were encountered during the testing of the APRA on the seven facilitated projects, meaning those whose testing was conducted with the facilitation of the research team. “Transitional Area” and “Exchange” were not encountered (as per discussions during the test meetings) in the projects. The exclusion of “Transitional Area” can be explained by the fact that each project was tested in the context of that project, and no comparison to other projects (in other transitional areas) were considered for the differences or issues to be noted. The exclusion of “Exchange” can be explained either by the non-existence of that type of parcel in the tested projects or by the non-awareness of the project teams of the issues, or both. The inherent factors and the projects that involved the issues are as follows, and these projects’ numbers are consistent with those given in Chapter 5:

- Transitional: no project;
- Acquisition: project 3;
- Ownership type: projects 3 and 10;
- Title issue: project 3;
- Mapping/Survey issue: projects 2, 3, 4, 5, and 8;
- Exchange: no project; and
- Number of parcels: project 4.

Although the two phases of this study involved two different groups of professionals and investigated two different samples of projects, the R/W issues identified seem to exhibit high rates of overlap. This overlapping significantly reinforces the findings and significance of both of the phases of the study together and each of them independently.

6.3. Inherent, Management, and External Factors in Right-of-Way Acquisition

The study of the inherent factors affecting the R/W schedule revealed seven significant factors, and from these factors a regression model for R/W acquisition Total Duration was built with a high R^2 of 0.82. While these results are encouraging and helpful, they still need to be improved upon for them to be effective in predicting the R/W acquisition total duration. There are a number of major reasons for this need. First, given the relatively small sample size of the projects and parcels, the model might have left out some factors that might have emerged to be significant had the sample size been substantially bigger. Second, the model might have failed to include some important inherent factors. The most important reason for this is probably that only project inherent factors were included in the model building while management factors might also have significant impacts. In fact, during both phases of this study, the research team was able to identify several important management issues. Some of the issues were identified in the first phase during the literature review, interviews, weighting workshops, and testing steps. Others were identified in the second phase during combined research team meetings and interviews with professionals while it is not unusual for issues to be identified in both phases of this study.

A factor is considered to be in the management category when it is relatively under the control of a State Department of Transportation and its personnel. It is common sense that management plays an important role in the scheduling of R/W acquisition. While this study did not aim at identifying and analyzing the management factors that may affect R/W acquisition, the study of the inherent factors that R/W acquisition entails gave the research team reasonable exposure to the management of this acquisition process and offered it a good position from which to discuss some of the observed management issues. The issues are briefly discussed and are as follows:

- Appraisal. A group of professionals estimated that it is reasonable for the project team to order appraisal eight calendar days after R/W release.

However, the data collected indicated that such appraisal occurs on average in 61 days. A period of three months is not uncommon. According to the same group of professionals, this delay is likely to be due to management. A large number of parcels that had a condemnation process either started (73 out of 172 parcels) or closed (35 out of 172 parcels) suggests that the appraisers might not have done their job well enough for the property owners to be convinced that they were being fairly paid. Of course, there could be other motivations for the owner not to accept the offer, but the high percentage (42.4 percent) of the parcels that had condemnation initiated warrants a closer investigation into the appraiser's work.

- Internal Coordination and Communication. The coordination and communication among the disciplines within the Texas Department of Transportation have been consistently noted as significant issues by the professionals who participated in both phases of this study. Such experts commented that different offices tend to do their jobs completely and then hand them over to other offices with minimum involvement of the personnel in the related offices. According to the professionals involved in the second phase, many of the detrimental mapping and survey issues could have been prevented if the R/W and design personnel would have been involved in the survey and R/W map development.
- External Coordination and Communication. The R/W acquisition process is economic, social, legal, and political in nature. The State DOT needs to interact with, and therefore is interdependent upon, other agencies, state or private, to acquire land for highway projects. For example, with the increasing amount of work that is outsourced to consulting companies, TxDOT is facing considerable challenges in coordinating and communicating with such consultants, especially when the outsourcing is

hybrid in nature, with the consultants doing the acquisition job and TxDOT taking care of the payment.

- Process and Procedure. The most obvious problem to the research team in terms of issues pertaining to the R/W processes and procedures is that TxDOT lacks an effective and systematic way to record, store, check, and analyze R/W data. This fact made it highly challenging for the research team to collect reliable data for the second phase of the study. Moreover, during the development of the APRA, and more specifically during the interview phase, it was noted that TxDOT did not maintain a process that encouraged the effective interaction among the offices during the PDP. This lack of effective interaction is believed to be one of the biggest causes of the delays in the PDP whose sub-processes are highly interactive, interdependent, and iterative.
- Personnel. There are two main aspects regarding personnel in the R/W acquisition, and these are shortage and competence. Some R/W administrators commented that the R/W teams in districts have been experiencing high turnover, which challenges the districts to recruit and train sufficient personnel to do the job. An R/W administrator even commented that "once a person leaves, you have the position vacant," meaning that vacancies are hard to fill. If this is true the personnel on hand is even more stretched to keep up with the job.

The APRA was the method and tool that could help to prevent the occurrence of negative impacts and minimize their effects in terms of both the inherent and management factors. For example, by pooling together in a single document all major issues of all disciplines in the project development process, the APRA can provide a good platform by which all parties can communicate, cooperate, and reconcile differences with one another.

Besides the inherent and management factors, external ones (those that are relatively beyond the control of a State Department of Transportation and not inherent to the projects and their parcels) may also have significant impacts on the R/W acquisition process. An obvious factor would be the economic climate. It is not rare for a project to be put on hold due to funding shortages or political reasons unknown to the district R/W acquisition project management team. However, these issues are well beyond the scope of this study.

Moreover, all factors of different kinds are likely interrelated, and they make it hard to understand thoroughly the factors that might have impact upon the PDP in general and R/W acquisition in particular. This study provides a significant stepping stone to the understanding and better management of the project development process. In the next two sections recommendations for practice and further research will be presented and discussed.

6.4. Recommendations for Practice

The APRA method as developed and tested in this study could effectively be used for identifying, assessing, and managing project development scope and risk. When combined with sound business planning, alignment, good project execution, and proper actions, it can greatly improve the project development process and the probability of either meeting or exceeding project objectives. The findings in the study of the R/W schedule should be helpful for a project team in predicting the schedule of and planning for R/W acquisition.

This research has been performed with the sponsorship of TxDOT, and much of the data collection for it was conducted in the state of Texas. Therefore, apart from the recommendations that are generic and applicable for all State Departments of Transportation, some recommendations are more specific and applicable to TxDOT in particular based on the clearer understanding of its processes obtained during the course of this research. What follows are recommendations for both Texas in particular and other states in general:

- **Commit to a systematic project development process:** While further research is still needed to provide definitive conclusions, the qualitative analysis of data collected during the development of the APRA from highly experienced professionals suggests that methods and tools like the APRA can help improve the effectiveness of the project development process through better communication and cooperation. Research from building and industrial construction sectors (CII 2007, 2008a, 2008b) also claims that effective planning in the early stages of projects can greatly enhance cost, schedule, and operational performance while at the same time minimizing the possibility of financial failures and disasters.

- **Promote a more open and collaborative environment in each of the districts:** Due to its uncertain and complex nature, the PDP requires a high level of interactions among projects participants and offices. During the research the participants frequently commented on the lack of open communication and collaboration among the projects participants, within or outside TxDOT. Open communication and clear collaboration would promote early identification of issues and proactive and concerted effort toward resolving problems.
- **Use the APRA to improve scope and risk management in project development:** An internal database of projects that are scored using the APRA should be developed. APRA scores at the various times during scope development are computed and compared to ultimate project success. Based upon the relationship between such APRA scores and subsequent project success, a basis could be established for the level of scope definition that is acceptable for moving forward from phase to phase. While the APRA can be helpful in promoting an open and collaborative project environment, it can also potentially be used as a tool to measure the level of scope definition and then predict project performance using historical data. Because the APRA was developed using data from Texas, it is highly relevant and ready to use for TxDOT.
- **Develop and maintain an effective system for recording, storing, checking, and retrieving PDP data:** A system that can effectively record,

store, and retrieve PDP data should be developed and implemented. Data recorded should prove to be invaluable for future studies that may lead to a better understanding and management of different sub-processes in the project development process. For TxDOT, an easy-to-use yet comprehensive system should be developed for the R/W acquisition process in all districts, one in which all involved parties can record, store, and utilize data for decision making. It would be a valuable source of data for state-wide research that may lead to improvements through the complex highway project process.

- **Utilize the findings from this research in planning for R/W acquisition:** Conclusions about the significant impact of inherent factors and the significant relationship among the sub-durations should be helpful for a project team in planning and implementing R/W acquisition. The final regression model could be used to assist the project team with predicting the acquisition time for a parcel based on the inherent factors of the project and parcel.

6.5. Recommendations for Further Research

Data collection when weighting the APRA elements was performed in Texas only, and therefore the weighting results are most suitable to projects in Texas. However, the list and descriptions of the APRA elements are substantially generic. In the second research phase, in spite of the positive findings, data were collected in Austin district of TxDOT only, and the impact on only R/W acquisition schedule was studied. It is therefore necessary to extend this research to other geographical locales. The following are select recommendations for further studies that can build upon this research:

- **Collect data on project performance and APRA scores:** This data collection would become possible when the APRA has been used for a certain period of time. The availability of the data would enable the analysis of the relationship between project performance and the level of project development scope definition, which could be illustrated by the

APRA score. Enhanced understanding of the relationship between project performance and the level of scope definition would allow a project team to predict project performance based on the level of scope definition of a new project.

- **Weight of the project elements in the context of other regions or states:** This weighting would better reflect the circumstantial characteristics and expert opinions of those areas. This extension could also be used for the purposes of benchmarking and generalizing. If the elements need to be re-weighted, a series of workshops is the recommended method to tap the expertise of experienced professionals.
- **Collect more and analyze data for the milestones and inherent factors:** This further data collection and analysis would be highly useful in refining the research results, especially the regression model for the R/W acquisition schedule. If more data would be collected in different areas than the Austin district, cross-regional comparison analysis could be performed. When more data are available for analysis, it is recommended that the methods used successfully in this research be utilized to ensure comparability of the research results.
- **Study the impacts of management and external issues:** These two types of issues should be included in studying the factors affecting the R/W acquisition and building models for predicting R/W acquisition duration. During the course of this dissertation research, various management and external issues were encountered and seemed to have significant impacts on the R/W acquisition schedule. Better understanding of these two types of issues, in conjunction with that of the inherent factors, would be critical for the success of highway project planning and execution.
- **Extend the list of the factors in this research and determine their impact upon R/W acquisition cost:** An enhanced understanding of factors affecting R/W acquisition time and cost would be highly useful for

the project team in improving its planning and acquisition. Furthermore, similar studies in other functions in the PDP, such as utility adjustment, design, and environmental procedure, would improve our understanding of the PDP.

CHAPTER 7. CONCLUSIONS

This chapter summarizes the research and concludes this dissertation. First, the following paragraphs briefly summarize the main findings of the research. Research objectives and hypotheses are then revisited, followed by a discussion of the limitations and the delimitations. Next the contributions of this research to the body of knowledge are discussed. Finally, conclusions about the entire research project round out this dissertation.

Of the first five phases of the project life cycle (Needs Assessment, Feasibility/Scoping, Preliminary Design, Detailed Design, and Construction,) the project development process covers the first four phases. This development process plays a crucial role in determining the overall effectiveness of a project, and it is a prime area for improvement in project delivery. Right-of-Way acquisition is one of the most important functions in the project development process and is always on the critical path of the project schedule. It is highly interactive with other functions. Therefore, the improvement of the R/W acquisition process requires both a mechanism for facilitating the collaboration among the functions and a better understanding of the R/W acquisition. Improvement in R/W acquisition would help streamline the PDP and thus make the project available earlier, adding to the public benefit.

The Advance Planning Risk Analysis method was developed to meet the first requirement. It is a method that, if used properly, can help effectively manage scope and risk during the project development process in all major functions, including Planning and Programming, Preliminary Design, Environmental Approval, ROW, Utilities, and PS&E. It can help the project development team control and manage critical project issues during project development. In addition, it can provide a platform for project participants to cooperate and coordinate project activities and responsibilities. It can help reconcile participants’ differences through discussions. It can also be a means for training new personnel. And the APRA can be used to anticipate project performance after being used for a certain period of time. In developing the APRA, the team took into account a great deal of relevant literature and expert knowledge. The method was tested and well received by potential users, and its potential benefits were recognized.

The study of the inherent factors affecting the R/W acquisition schedule involved rigorous data collection and analysis. In this process, the expertise of R/W professionals was utilized. The results showed that inherent project and parcel factors can be identified and their significance can be statistically determined. All but two of the 15 inherent factors were found to have a significant impact upon or relationship with at least one of the R/W durations. Six of them were found to have significant impact upon or relationship with at least four of the R/W durations. The findings on the significance should be helpful to any project team in planning for R/W acquisition. The regression model built for the R/W acquisition total duration is statistically significant and useful (with a R^2 of 0.82) in predicting the duration using inherent factors. Altogether, this study of the inherent factors contributes to the understanding of the R/W acquisition process and provides helpful findings for actual industry practice.

7.1. Research Objectives and Hypotheses Revisited

All of the five research objectives were met by the research. Each of them is revisited below, and how they were met by the research is discussed as follows:

- **Objective 1: Identify and categorize critical project development scope elements.** Project development scope elements were identified using various sources of data including interviews with subject matter experts. They were grouped into 12 categories and three sections, which meet a number of criteria in both organization and functionality.
- **Objective 2: Determine the relative weights of the critical project development scope elements.** The identified scope elements were weighted based on their relative importance to the project outcome. The weighting process was rigorous and involved 46 experienced professionals and the combined research team of experienced professionals and researchers.
- **Objective 3: Develop a systematic scope and risk management method to assess and monitor the project development scope definition using the critical scope**

elements. The APRA was developed as the method to reach the research goals. It is both a scope and risk management method that can be useful for the project development team. The method is accompanied by a guideline of how to use it as well as a computer tool, which has its own guidelines, to assist in using the method.

- **Objective 4: Identify and analyze the project and parcel inherent factors that have a significant impact on the R/W acquisition schedule.** Project and parcel inherent factors were identified with input from R/W experts. The factors were analyzed, and positive findings were made regarding their individual impact on R/W acquisition total duration and sub-durations.

- **Objective 5: Build a model for predicting the R/W acquisition schedule using the inherent factors.** The inherent factors were also used to develop a model for predicting the R/W acquisition schedule. The model that was built is useful in predicting the R/W acquisition total schedule, with an F value of 69.6, an R^2 of 0.815, and an adjusted R^2 of 0.803.

The research also confirmed the two main hypotheses, as explained below:

- **Hypothesis 1.** The APRA, as developed using the weighted scope elements, is a systematic method for the project development team to use to identify, assess and monitor critical project development issues across all major functions in the PDP.

- **Hypothesis 2.** With the extensive involvement of the project development professionals, the inherent factors that significantly affect the R/W acquisition schedule were identified and analyzed statistically. The confirmation of these hypotheses provides a stepping stone to furthering the research of inherent factors in project development.

7.2. Limitations and Delimitation

Due to the scope and the data collection process, the research has a number of limitations. Some of the limitations and the delimitation of the research are discussed below:

- In identifying and defining the PDP scope elements, documentation at both state and federal levels was used in conjunction with other publications and experts' opinions. The elements and their descriptions are, therefore, generic and applicable to highway projects in all states.

- In determining the importance of the scope elements, only data in the state of Texas were used. The elements' weights are therefore more applicable to the states whose PDP practices are similar to those of Texas.
- In determining the importance of the scope elements, only schedule and cost impacts were considered. The interpretation of the elements' importance should, therefore, be based on these impacts.
- In statically analyzing the inherent factors, only data from projects managed by TxDOT's Austin district from five years before the start of data collection were considered. The results regarding the significant inherent factors affecting R/W acquisition schedule are, therefore, more applicable to Texas and similar states as well as metropolitan areas like Travis county.
- Even though the positive findings and model are believed to be highly useful, the relatively small sample size warrants careful use of the research results, and it should be noted that a larger sample size might have provided different results.
- Only project and parcel inherent factors were identified and analyzed; those factors on which the project development team has relatively direct influence or those that are beyond the control of TxDOT were not considered. Research including management and external factors would likely improve the model's usefulness.
- This research considered only highway projects that were performed by state agencies using the traditional procurement method (Design-Bid-Build). Data were not collected for Design-Build projects and from the private sector. Therefore, findings by this research should be interpreted with this limitation in mind.

7.3. Contributions

This research makes a number of contributions to the body of knowledge, especially in the area of project development of highway projects. Major contributions include the following:

- **The identification of critical highway project development scope elements:** The list of elements pools together the scope of work in highway project development and helps create a better big picture of the process.
- **The relative importance of the scope elements:** The weights of the scope elements developed through the input of 46 experts provide a better understanding of the relative importance of the scope elements in project development.
- **The scope and risk management method, Advance Planning Risk Analysis (APRA):** This method provides a systematic mechanism for assessing and monitoring the project development scope definition using the critical scope elements. It also suggests that a systematic scope and risk management method in highway project development is possible and could be effective, especially if multiple key stakeholders are involved in the planning effort.
- **The regression model for R/W acquisition total duration:** This significantly useful model, while being a contribution itself, suggests that using historical data and inherent factors can be helpful to the project team in predicting the R/W acquisition schedule.
- **The findings on the significant impacts of inherent factors on R/W acquisition durations:** The findings are helpful in planning for R/W acquisition and suggest that research into this area will be productive and a beneficial addition to the body of knowledge.

7.4. Conclusions

Motivated by the criticality of the R/W acquisition sub-process in the highway project development process, this research has the purpose of improving this acquisition process. However, R/W acquisition is not a stand-alone process, but a highly interactive one both with and interdependent with other sub-processes of the PDP. The APRA was therefore developed in order to provide a project development team with a tool that can quantitatively capture all major issues in all major disciplines of the PDP. The APRA's 59 elements with descriptions provide a common platform of communication and cooperation among the disciplines in the PDP. Its weighted elements allow the project team to quantitatively assess the scope definition and riskiness of a project at a given point in time. The APRA was developed with enormous help from R/W subject matter experts and was well received by those who participated in the testing process. The APRA can be considered as a high level method and tool that covers all major issues in the project development process.

Improving the R/W acquisition sub-processes should not stop at the high level of the APRA but should continue with the goal of facilitating a deeper understanding of the sub-processes. In the second phase of this research, an exploratory study of the inherent factors and their impacts on the R/W acquisition schedule was conducted. This phase identified, shortlisted, and analyzed 15 inherent factors and concluded that seven of them have statistically significant impacts on the R/W acquisition total duration. It went further by developing a regression model for predicting the R/W acquisition total duration. The model developed is highly significant and helpful, having an R^2 of 0.82.

The close involvement of R/W professionals in the research process allows for strong recommendations to be made for improving the R/W acquisition process in particular and the PDP in general in actual industry practice. While some of the recommendations are generic to all state Departments of Transportation, some of them are more applicable and relevant to TxDOT. One example of the recommendations stemming from this research is to develop an effective system for recording, storing, and retrieving PDP data. This system is believed to be extremely helpful in conducting research for better understanding of and improvements to the PDP.

As discussed earlier in this chapter, the objectives of this research were met and the hypotheses accepted. However, given both the success of this research and its limitations, recommendations were made for further research, either to extend the research results to other related aspects or to validate (or invalidate) the findings of this research. For example, it was recommended that the APRA elements be weighted in other areas; management and other external issues should also be included in further research to improve the understanding and predictability of the R/W acquisition schedule.

Finally, this research is believed to make significant contributions to the body of knowledge by providing a stepping stone toward the better understanding and improvement of the PDP process in general and the R/W acquisition process in particular. Continuing to build upon its findings and with the limitations in mind, further research in this area and direction should be promising, productive, and highly valuable. The methods and approaches used successfully in this research should be utilized to ensure comparability of the research results.

Appendix 1. Guide for Interview with Professionals in the Project Development Process

Research Introduction & Project Confidentiality

The Center for Transportation Research (CTR – UT) and the Texas Department of Transportation (TxDOT) are currently working on a research endeavor to optimize the identification of right of way requirements throughout the project development process. Research on this project (TxDOT #0-5478) commenced in the fall of 2005 and is scheduled to conclude with the presentation of project deliverables to RTI in fall of 2007. Presently, CTR staff is in the process of obtaining valuable information from various TxDOT districts and divisions through structured interviews. The research team is composed of the following TxDOT and CTR officials:

<u>TxDOT Team Members</u>

Tommy Jones, *Project Director*	TxDOT – Abilene District
Dale Booth	TxDOT – Tyler District
Kristy Gardner	TxDOT – Abilene District
Travis Henderson	TxDOT – Dallas District
Sylvia Medina	TxDOT – RTI (RMC 3)
Tom Yarbrough	TxDOT – RTI (RMC 3)

<u>CTR Research Staff</u>

G. Edward Gibson, *Research Supervisor*	CTR – UT
Carlos Caldas, *Co-PI*	CTR – UT
Tiendzung Le	CTR – UT
Michael Thole	CTR – UT

Key project objectives are as follows:

1. To develop a Best Practice Model for engineers and designers during the project development process.
2. To develop an electronic guide of design-related factors to determine the ROW requirements determination.
3. To develop a tool to perform a sensitivity analysis of the certainty associated with the ROW requirements determination.

4. To synthesize data-driven findings into recommended strategies and tactics for expediting these processes, including, if applicable, recommendations for process changes and/or policy changes.

The results of this questionnaire will help determine the design-related factors that are essential in ROW requirements determination. Moreover, it can provide insight on strategies for recommendation and possible process/policy changes as well.

Confidentiality Statement

The information gathered in this questionnaire will only be used for research purposes as indicated above and during the interview. Any personal information will be held in strict confidentiality.

Personal Professional Information:

1) Could you give us a brief introduction on your current position with TxDOT:
    - Job responsibilities and deliverables produced?
    - Relation to PDP (Project Development Process) & attaining ROW (Right of Way)?
    - What is the nature of projects you work on?

2) How does your position directly interface with ROW issues?

3) Have you had any prior experience working in other districts, divisions, or capacities for TxDOT that resulted in your interfacing with ROW issues?

4) Have you personally participated in any TxDOT training programs related to PDP or ROW?
    - Which programs?
    - To what extent are they beneficial or insufficient?

5) Are most of the projects you work on considered rural, urban, or a combination of the two?

6) In what capacity do you work on several projects simultaneously?

Current Processes, Tools, and Techniques for ROW Development:

1) Do you, or does your office, have specific objective measures set up to efficiently plan projects that are inclusive of ROW?
    - Implementation plans, roadmaps, checklists, etc?
    - Cost and schedule control diagrams?
    - Prioritized list of activities?

2) What TxDOT project development guides, tools, or documentation are you aware of that can assist in performing your job functions in the PDP?
    - How are they integrated into planning process?
    - When are they implemented?
    - Who is involved in carrying out the tool?
    - Who are the key providers of data for input into tool?

    (As the interviewer, we should introduce the following information if not mentioned by the interviewee – PDP Manual, PDP Flowchart, PS&E Manual, ROW Manual, ROW Process Map, ROWIS, RUDI)

3) What are your purposes in using the guides mentioned above, and how effective is the information obtained by using these tools in attaining your overall planning objectives?
    - Specific attributes of the current tools?
    - What hinders development or renders tool difficult to use?

4) Does your office maintain processes other than the ones we've described above, developed locally for your office's use?
    - How were they created and by whom?
    - Why are they implemented instead of/in addition to the general TxDOT tools?
    - How difficult is it to integrate these into the project development process?
    - Is it possible to obtain a copy of these materials?

5) Do you have current methods for tracking project development in terms of ROW acquisition (schedules, matrices, etc.)?

6) Can you identify deliverables that you produce, as part of your job description, containing ROW information or information gathered from ROW officials?
    - Which deliverables particularly impact ROW development?
    - How often do these deliverables get changed during planning & execution?

Problems Resulting from Current Practices:

1) What do you feel are the biggest constraints to your daily activities regarding the definition of ROW issues during the project development process?
(These do not necessarily need to be specific activities, but can incorporate general concerns, such as social, economic, schedule, and communication requirements.)

2) Do you know of anything that is currently being done to ameliorate these concerns? Do you have any targeted ideas for improving these concerns?

3) Are there any apparent process-related problem areas in project planning and ROW development?
    - What in your opinion are the root causes of these failures in the system?
    - Which seem to have the biggest impact on project objectives?
    - Which seem to require substantial efforts in order to be overcome?

4) Which problems, or potential problems, result from the interfacing of various parties, districts, and divisions within TxDOT or the project community?

Key Stage Factors in the Project Development Process:

Upon completing questions related to the general practices employed by the TxDOT district, we would like to detail the five stages of project development, indicated in the PDP Manual. Interviewees will only respond to the areas of project development in which they are functioning as team members. These stages are as follows:

Planning & Programming

1) Who is involved in this sub-process regarding ROW development?

2) How do you evoke public involvement in this stage of the project and how does your office interact with the public regarding ROW concerns?

3) What meetings or other interactions between project and ROW stakeholders take place during this sub-process?

4) What ROW issues, defined or examined in this stage, are in your opinion, critical to project development?
    - Barriers/difficulties (e.g. personnel, cost, communication, time)?

- Requirements/pressure (e.g. regulatory, other legal)?

5) What special ROW issues result from jurisdictional issues?

6) What are current performance characteristics for this sub-process and how are they measured?
    - How long does this process last?
    - How much money is authorized for planning & programming?
    - What is the quality of the information gathered in this stage?

7) Are delivery and contracting strategies discussed in terms of impact on ROW prior to design and execution?

Preliminary Design

1) How do you obtain ROW input information for the preliminary design phase? (e.g. from owner, utility companies, public)

2) What ROW issues, defined or examined in this stage, are in your opinion, critical to project development?

    - Specific Information?
    - Coordination?
    - Approval?

3) What interactions take place to organize ROW information during the design phase and who is involved?
    - Public involvement?
    - Division & District meetings?
    - Design deliverables?
    - Legal & Jurisdictional issues?

4) What are current performance characteristics for this sub-process and how are they measured?
    - How long does this process typically last?
    - What is the quality of the deliverables relating ROW and Design? How often are they resubmitted and reissued?

5) What critical problem areas can you point out in regards to ROW development in the design phase?

Environmental

1) What are the environmental regulatory requirements associated with ROW development?

2) What are your current processes/guidelines to meet these requirements?

3) Who is involved in Right Of Way Division and Environmental Division interfacing?

4) What ROW issues, defined or examined in this stage, are in your opinion, critical to project development?
    - Information
    - Process
    - Approval
    - Public

5) How do these issues affect ROW in particular and PDP in general?
    - How long is the revision process for ROW development (or schedule impact) if environmental problems are found?

6) What should be done to improve the situation?

ROW & Utilities

1) Who is involved in this sub-process and what additional members can you foresee as beneficial?
    - At what point are local utilities brought in to the planning process?
    - What information do utilities companies provide that TxDOT does not have initial access to?

2) How do project team members and the public interact/communicate/coordinate to produce a detailed list of ROW requirements prior to release?

3) What ROW issues, defined or examined in this stage, are in your opinion, critical to project development?

4) What are the biggest obstacles and difficulties in this sub-process?
   (Attention may be paid to land owners and utility companies?)

5) What are current performance characteristics for this sub-process and how are they measured?

6) What needs to be improved in this sub-process and do you have any recommendations?

Post-ROW

1) How do Right of Way Division employees maintain their initial interactions with other project participants, stakeholders, and the public?

2) Are there inter-Division deliverables that still need to exist during this stage regarding the effective execution of ROW acquisition and maintenance?

3) What are the most critical issues after ROW release and prior to construction?
   - What maintenance and operational factors can be defined early in the project development process? Are these issues brought to light early on?

4) What can be done to improve this sub-process in terms of present ROW inefficiencies and definition?

Tool Definition:

1) In summary to our research, we will propose a tool that can be utilized to guide TxDOT personnel to efficient ROW definition in the project development process. Do you have any suggestions for its development?
   - What form of appearance should it take? *(web-based, computer application, document-based)*
   - What should be the main functions and contents of the tool?
   - What should be its inputs and outputs?
2) What stage of the project development process do you feel could best benefit from the implementation of this tool? At which point should it be implemented?

3) How would you like this tool to be used? (*checklist, decision-maker, identifier)*

Please feel free to comment on any additional areas, that you feel could be beneficial to this project, that were not already discussed.

Appendix 2. Scope Elements and Their Descriptions

The following descriptions have been developed to help generate a clear understanding of the terms used in the Unweighted Project Score Sheet. Some descriptions include checklists to clarify concepts and facilitate ideas when scoring each element. Note that these checklists are not all-inclusive and the user may supplement these lists when necessary. Moreover, for specific information regarding certain processes and tasks during the Project Development Process, a listing of Texas Department of Transportation (TxDOT) requirements is included for many of the element descriptions.

The descriptions are listed in the same order as they appear in the Unweighted Project Score Sheet. They are organized in a hierarchy by section, category, and element. The Unweighted Project Score Sheet consists of three main sections, each of which is a series of categories that have elements. Scoring is performed by evaluating the levels of definition of the elements. The sections, categories, and elements are organized as follows:

SECTION I – BASIS OF PROJECT DECISION

This section consists of information necessary for understanding the project objectives. The completeness of this section determines the degree to which the project team will be able to achieve unification in meeting the project's business objectives.

Categories:

A – Project Strategy

B – Owner Philosophies

C – Project Requirements

SECTION II – BASIS OF DESIGN

This section consists of geotechnical, hydrological, environmental, structural, and other technical design elements that should be evaluated to fully understand impacts on the acquisition of right-of-way. Similarly, this section includes a number of right-of-way requirements prior to acquisition, occurring simultaneously with preliminary design.

Categories:

D – Site Information

E – Location & Geometry

F – Structures

G – Design Parameters

H – Installed Equipment

SECTION III – EXECUTION APPROACH

This section consists of elements that should be evaluated to fully understand the requirements of the owner's execution strategy and approaches for detailed design, R/W acquisition, utility adjustments, and construction.

Categories:

I – Acquisition Strategy

J – Deliverables

K – Project Control

L – Project Execution Plan

The following pages contain detailed descriptions for each element in the APRA.

SECTION I – BASIS OF PROJECT DECISION

A. PROJECT STRATEGY

A.1. Need & Purpose Documentation

The need for a project may be identified in many ways, including suggestions from maintenance supervisors, area engineers, transportation planners, local elected officials, developers, and the public. This process typically includes site visits, seeking input from individuals with relevant knowledge. Documentation should result in assessing the need and purpose of a potential project based on factual evidence of current and future conditions. This documentation must consider how the project will address previously determined problems and inefficiencies, in language that is understandable to the general public. It will eventually serve as the basis for identifying, comparing, and selecting alternatives. Issues may include:

- ❑ Project scope and definition
- ❑ Community concerns and critical issues
- ❑ Consultation with local public officials regarding supportive legislation
- ❑ Multi-modal alternatives and inter-modal relationships
- ❑ Current operational/maintenance inefficiencies and high costs
- ❑ Current and future economic development needs
- ❑ Adjacent properties and transportation facilities
- ❑ Site visits and interviews
- ❑ Capacity improvement needs:
    - ❑ Existing levels of service
    - ❑ Traffic modeling of future travel demands
    - ❑ Trend analysis and forecasted growth
- ❑ Safety improvement needs:
    - ❑ Accident frequency and severity
    - ❑ Conformance with current geometric standards
    - ❑ Pavement and bridge structure conditions
- ❑ Other

TxDOT Requirements:

- ❑ *"Need & Purpose Statement"*

A.2. Investment Studies & Alternatives Assessments

Various studies address possible alternatives when the solution is unknown. In some cases, these studies may show that the project is not economically justifiable – or that it has so many environmental impacts that it is not viable. Early determination of these findings will avoid unnecessary expenditure of funds on preliminary engineering and related costs. These studies may take the form of feasibility/route studies or major investment studies. Issues of concern during study processes include:

- ❑ Stakeholder activity responsibilities
- ❑ Consultant reviews and selection
- ❑ Route requirement determinations
- ❑ Corridor selection and major alternatives
- ❑ Preliminary surveys:
    - ❑ Population densities
    - ❑ Trends in land use and development
    - ❑ Travel patterns
    - ❑ Travel trends
    - ❑ Directional distribution and volumes
    - ❑ Economic, social, and environmental conditions
- ❑ Existing traffic data at governmental levels (e.g., city, county, state)
- ❑ Alternative profile layouts and preliminary mapping
- ❑ Multi-modal alternatives and inter-modal connections
- ❑ Toll lane and high occupancy vehicle lane inclusions
- ❑ Railroad corridor preservation
- ❑ Preliminary public involvement
- ❑ Major investment study needs
- ❑ Transportation Planning:
    - ❑ Short-term
    - ❑ Medium-term
    - ❑ Long-term
- ❑ Other

TxDOT Deliverables and Processes:

- ❑ *"Request for Feasibility Study" preparation, execution, and approval*
- ❑ *Unified planning work program (UPWP)*
- ❑ *Statewide transportation implementation plan (STIP)*
- ❑ *Long-range transportation plan (LRTP)*

A.3. Programming & Funding Data

Authorization of projects within local, governing transportation plans is a typical requirement prior to executing funding agreements. As part of the authorization process, relatively accurate cost estimates must be prepared, assessing funding directed towards preliminary engineering, construction, right-of-way acquisition, utility adjustment, maintenance, and other project expenses. As such, strategic measures must be in place for determining the sources, levels, and forms of funding available to the project, as it competes against others for limited funds. Issues to consider include:

- ❑ Initial construction cost estimates
- ❑ Initial right-of-way cost estimates
- ❑ Cost drivers, such as:
    - ❑ Utility adjustment costs
    - ❑ Environmental/mitigations costs
    - ❑ Significant traffic control costs
- ❑ Cost-benefit analysis
- ❑ Sources and forms of funding:
    - ❑ Local government entities
    - ❑ State and federal agencies
    - ❑ Private entities
- ❑ Breakdown of funding participation
- ❑ Congruity with local transportation programs
- ❑ Economically disadvantageous community funding
- ❑ Level of local level community support
- ❑ Unusual funding scenarios
- ❑ Other

TxDOT Deliverables and Processes:

- ❑ *"Programming Assessment Study" preparation and execution*
- ❑ *Design and Construction Information System (DCIS) estimate update*
- ❑ *Financial Management Information System (FMIS) estimate update*
- ❑ *"Long Range Project" status execution under Unified Transportation Plan (UTP)*
- ❑ *"Advanced Funding Agreement" preparation and execution*

A.4. Key Team Member Coordination

Establishing a positive alliance among all project team members facilitates the potential for an efficient, successful outcome – particularly if this alliance is achieved early during the planning process. Infrastructure projects typically involve many different team members existing in both the public and private sectors. All key team members must be informed of project decisions and given the opportunity to attend project planning meetings, in order to minimize the impacts on sequential activities. Key team members may include:

- ❑ Right-of-way planning
- ❑ Traffic planning and programming
- ❑ Design engineering
- ❑ Environmental planning
- ❑ Construction engineering
- ❑ Operations and maintenance
- ❑ Consultants
- ❑ Local governmental authorities:
    - ❑ Local/state government officials

- ❑ Local public agencies
  - ❑ Environmental resource agencies
  - ❑ Budgeting officers
- ❑ Federal authorities (e.g., Federal Highway Administration (FHWA) and Federal Transit Administration (FTA))
- ❑ Other

TxDOT Meetings:

- ❑ *Feasibility Scoping Meeting*
- ❑ *Project Concept Conference*
- ❑ *Project Design Conference*
- ❑ *Utility Coordination Meetings*

A.5. Public Involvement

Public involvement is an integral part of project development. Every project has to afford some level of public involvement to inform the public of project scope issues and to measure public attitudes regarding the development process. The level of public involvement is dependent upon a number of social, economic, and environmental factors, along with the type and complexity of the project. Public involvement efforts may include meetings with key stakeholders, including affected property owners, public meetings, and public hearings. Issues to consider include:

- ❑ Policy determinations regarding public involvement
- ❑ Notification procedures and responsibilities
- ❑ Identification of key stakeholders
- ❑ Identification of utility providers
- ❑ Types of public involvement:
  - ❑ Meetings with affected property owners
  - ❑ Public meetings
  - ❑ Public hearings
- ❑ Local support and/or opposition
- ❑ Public involvement strategies after project approval
- ❑ Press releases and notices
- ❑ Available website content
- ❑ Other

TxDOT Deliverables and Processes:

- ❑ *Incorporate into "Draft Environmental Impact Statement" (DEIS)*
- ❑ *Incorporate into "Final Environmental Impact Statement" (FEIS)*
- ❑ *Written summary of proceedings*
- ❑ *"Opportunity for Public Hearing" notice*
- ❑ *"Public Hearing" notice*

B. OWNER/OPERATOR PHILOSOPHIES

B.1. Design Philosophy

A list of general design principles should be developed to achieve a completed project that fulfills a functional requirement and also assimilates into the existing roadway infrastructure. Issues to consider include:

- ❑ Design life
- ❑ Safety requirements
- ❑ Multimodal Requirements
- ❑ Aesthetics requirements
- ❑ Compatibility with long-range transportation goals
- ❑ Environmental sustainability
- ❑ Access management
- ❑ Geometric/traffic speed
- ❑ Community image
- ❑ Other

B.2. Operating Philosophy

A list of general design principles should be developed to preserve the level of service desired and sufficient transportation capacity over an extended period of time. This particularly focuses on developing strategic operations plans to prevent sub-optimal capacity-related problems. Issues to consider include:

- ❑ Daily level of service requirements
- ❑ Directional volume and lane change requirements
- ❑ Operating timetables
- ❑ Technological needs assessment
- ❑ Future improvement schedule
- ❑ Flexibility to change layout
- ❑ The owner/operator of the facility
- ❑ Traffic control plans and detour availability
- ❑ Utilities location (e.g., in median, under pavement)
- ❑ Other

B.3. Maintenance Philosophy

A list of general design principles should be developed to lay out guidelines to maintain adequate roadway operations and safety over an extended period of time. Furthermore, a specific traffic control plan should be in place for the project corridor, if traffic operations interface simultaneously with maintenance operations. Issues to consider include:

- ❑ Scheduled shut-down frequencies and durations
- ❑ Traffic monitoring requirements

- ❑ Equipment access needs and provisions
- ❑ Traffic control plans and detour availability
- ❑ Environmental conservation programs
- ❑ Selection of materials for design and construction
- ❑ Other

B.4. Future Expansion & Alteration Considerations

The possibility of expansion and/or alteration of this transportation facility and site should be evaluated. These considerations consist of a list of items that will facilitate the potential expansion or evolution of facility use. Issues to consider may include:

- ❑ Regional transportation plans
- ❑ Statewide transportation plans
- ❑ Interface with future urban development sites
- ❑ Expected population densities along corridor
- ❑ Availability for added capacity and widening:
  - ❑ Vertical added capacity
  - ❑ Horizontal added capacity
- ❑ Availability for interchanges, access ramps, and frontages
- ❑ Pending and future traffic regulations
- ❑ Corridor preservation (i.e., sloped to grade, with potential for retaining walls in the future)
- ❑ Other

C. PROJECT REQUIREMENTS

C.1. Functional Classification & Use

An essential step in the design process is to determine the functions that the facility is to serve. The two major functions to consider in classifying a roadway are access and mobility. In added capacity projects, a distinction must be made as to the existing and prescribed classification. Important in this classification is whether the facility is on or off the state system. Classification often determines funding requirements and allocation. Functional types to consider include:

- ❑ Principal arterial roads (freeways):
  - ❑ Urban freeway
  - ❑ Rural freeway
- ❑ Minor arterial roads:
  - ❑ Urban frontage road
  - ❑ Rural frontage road
- ❑ Collector roads:
  - ❑ Urban multi-lane
  - ❑ Rural multi-lane

- ❑ Local roads and streets:
  - ❑ Urban street
  - ❑ Suburban street
  - ❑ Rural one-lane
- ❑ Bike and pedestrian trails
- ❑ Other

C.2. Evaluation of Compliance Requirements

Project planning requires adherence to various local, regional, and statewide plans for efficient and comprehensive tracking. As part of project development, applicable requirements must be determined and complied with. Issues to consider for compliance include:

- ❑ Regional transportation plans
- ❑ Statewide transportation plans
- ❑ Local master plans and documentation
- ❑ Related investment studies and reports
- ❑ Local entity input:
  - ❑ Municipal departments
  - ❑ Chambers of commerce
  - ❑ Public utilities
  - ❑ Public housing
  - ❑ Railroads
  - ❑ Ports and harbors
  - ❑ Transit authorities
  - ❑ Governmental councils
- ❑ Other

TxDOT Transportation Plans:

- ❑ *Texas Transportation Plan (TTP)*
- ❑ *Metropolitan Transportation Plan (MTP)*
- ❑ *Coastal Zone Management Plan (CZMP)*
- ❑ *Transportation Improvement Program (TIP)*
- ❑ *Statewide Transportation Improvement Program (STIP)*
- ❑ *Unified Transportation Program (UTP)*

C.3. Survey of Existing Environmental Conditions

A preliminary survey consists of fieldwork and data acquisition from a variety of sources, including previous surveys, geographic information systems, and resource agency databases. Identifying problematic issues at an early stage in the project development process enables adequate time to address and mitigate these concerns. Issues to consider include:

- ❑ Natural resource surveys:
    - ❑ Endangered species
    - ❑ Wetland status
    - ❑ Bodies of water
    - ❑ Existing and potential park system land
    - ❑ Permit needs
- ❑ Cultural resource surveys:
    - ❑ Historical preservation
    - ❑ Existence of cemeteries
    - ❑ Archaeological sites
- ❑ Air quality surveys:
    - ❑ Mobile source pollutants
    - ❑ Air quality analysis
    - ❑ Congestion mitigation-air quality
- ❑ Noise surveys:
    - ❑ Evaluation of need for abatement
- ❑ Hazardous materials:
    - ❑ Existing land use
    - ❑ Superfund and regulatory agency database review
    - ❑ Underground storage tanks
    - ❑ Site visits
    - ❑ Local inhabitant interviews
- ❑ Socioeconomic Impacts
- ❑ Other

C.4. Determination of Utility Impacts

Infrastructure projects often necessitate the adjustment of utilities to accommodate the design and construction of proposed transportation facilities. Failure to mitigate utility conflicts in the design process or to relocate facilities in a timely manner can result in unwarranted delays and increased project costs. Issues to consider include:

- ❑ Field verification of existing utilities facilities
- ❑ Field verification with proposed alignment
- ❑ Necessary utility facility repair and modernization
- ❑ Action plans for utility adjustments
- ❑ Physical constraints to utility placement
- ❑ Schedule impact of utility relocations and adjustments
- ❑ Determination of utility location in state right-of-way
- ❑ Local ordinances or industry standards
- ❑ Safety clearances requirements
- ❑ Other

TxDOT Requirements:

In Texas, public utilities have been granted the right to occupy State right-of-way. These rights are extended, provided that utility use will not interfere with safety of the traveling public nor the State's ability to construct and maintain highways.

- ❑ *Utility Accommodation Rules (UAR) compliance*
- ❑ *Texas Administrative Code, Environmental, 290.44 (TAC) compliance*

C.5. Value Engineering

Value Engineering (VE) studies may be used to assess a project's overall effectiveness or how well the project meets identified needs. VE is another tool that may be used in alternative selection. Study findings may show that redesign of an alternative is needed, in which case schematics may require revisions. VE is designed to gather expertise and experience of individuals to produce the most effective solution to the transportation need. Issues to consider include:

- ❑ Policy requirements and processes
- ❑ Team member and team leader identification
- ❑ Strategic resource collection and studies:
    - ❑ Redundancy factors
    - ❑ Over capacity factors
    - ❑ Life-cycle and replacement costs
    - ❑ Environmental clearance impacts
    - ❑ Other
- ❑ Report preparation and recommendations
- ❑ Session attendance requirements
- ❑ Approved response submittals
- ❑ Planning document revisions
- ❑ Other

SECTION II – BASIS OF DESIGN

D. SITE INFORMATION

D.1. Geotechnical Characteristics

Geotechnical and soil test evaluations of the project corridor should be developed. Issues to consider include:

- ❑ General site descriptions (e.g., terrain, spoil removals, areas of hazardous waste)
- ❑ Soil composition and strata structure
- ❑ Potential soil expansion considerations
- ❑ Soil densities and compaction requirements
- ❑ Seismic requirements
- ❑ Foundation requirements:
    - ❑ Allowable bearing capacities
    - ❑ Pier/pile capacities
- ❑ Water table
- ❑ Groundwater flow rates and directions
- ❑ Soil percolation rate and conductivity
- ❑ Existing contamination
- ❑ Karst formations
- ❑ Man-made/abandoned facilities
- ❑ Soil treatment and remediation needs
- ❑ Boring tests and test pits
- ❑ Other

D.2. Hydrological Characteristics

Hydraulic information should be reviewed and analyzed at a high level prior to selection of alternatives and detailed design. This information is necessary for determining hydraulic structural requirements and detention facilities, as well as preliminary right-of-way requirements. Issues to consider include:

- ❑ Drainage basin characteristics:
    - ❑ Size, shape, and orientation
    - ❑ Slope of terrain
    - ❑ Watershed development potential
    - ❑ Geology
    - ❑ Surface infiltration
    - ❑ Antecedent moisture condition
    - ❑ Storage potential (e.g., overbank, wetlands, ponds, reservoirs, channels)
- ❑ Flood plain characteristics
- ❑ Soil types and characteristics
- ❑ Ground cover and erosion concerns, including scour susceptibility

- ❑ Meteorological characteristics:
  - ❑ Precipitation types and amounts
  - ❑ Peak flow rates
  - ❑ Hydrographs
  - ❑ Special precipitation concerns
- ❑ Storm water runoff control
- ❑ Potential impacts of future development
- ❑ Other

D.3. Surveys & Planimetrics

Once it has been determined that a corridor needs to be studied, a reconnaissance of the corridor is conducted. This includes a study of the entire area. The study facilitates the development of one or more routes or corridors in sufficient detail to enable appropriate officials to recommend which will provide the optimum location. Issues to consider include:

- ❑ Right-of-entry requirements
- ❑ Surveying consultant requirements
- ❑ Current aerial photographic displays
- ❑ Existing right-of-way maps/inventory
- ❑ Preliminary survey, including recovery of existing monumentation
- ❑ Topography (contours)
- ❑ Existing structure locations
- ❑ Grid ticks and centerlines
- ❑ Geotechnical summaries
- ❑ Utility information
- ❑ Affected area maps
- ❑ Special property owner concerns
- ❑ Other

US Requirements:

- ❑ *Use of Subsurface Utility Engineering (SUE)*

D.4. Permitting Requirements

Permitting usually begins concurrently with surveys and continues throughout project construction. Personnel responsibilities should be specific to each permit and clearly delineated. In many cases, permits must be obtained before further approval of project development activities and site access. Issues to consider include:

- ❑ Waterway permits
- ❑ Wetland permits
- ❑ Flora and fauna permits

- ❑ Resource agency permits
- ❑ Historic and cultural association permits
- ❑ Pollutant and emissions permits
- ❑ Approved points of discharge permits
- ❑ Grading and erosion permits
- ❑ Local jurisdictional permits
- ❑ Other

US Requirements may include:

- ❑ *U.S. Army Corps of Engineers (USACE) and U.S. Coast Guard (USCG) permits*
- ❑ *Clean Water Act Section 404 requirements*
- ❑ *Endangered Species Act requirements*

D.5. Environmental Documentation

Project environmental classification drives the type of environmental documentation that is required. Environmental documentation should provide a brief summary of the results of analysis and coordination, as well as information about of the social, economic, and environmental impacts of a project. This includes a determination of what decision should be made on a project's construction, location, and design. In addition, the document should describe early interagency coordination and preliminary public involvement, including estimates of time required for milestones.

Types of environmental documentation in the U.S. include:

- ❑ *Environmental Assessments (EA)*
- ❑ *Environmental Impact Statements (EIS)*
- ❑ *Categorical Exclusions (CE)*
- ❑ *Potential Outcomes*
    - ❑ *Findings of No Significant Impact (FONSI)*
    - ❑ *Notice of Intent (NOI)*
    - ❑ *Record of Decision (ROD)*
    - ❑ *Categorical Exclusion (CE)*
- ❑ *Section 4F Documentation (e.g., parks and recreation areas, refuges, cultural resources, and other sites)*
- ❑ *Other*

(Note: As defined in the U. S. National Environmental Policy Act (NEPA), three levels of environmental analysis exist. At the first level, an undertaking may be categorically excluded (CE) from a detailed environmental analysis if it meets certain criteria which a federal agency has previously determined as having no significant environmental impact. At the second level of analysis, a federal agency prepares a written Environmental Assessment (EA) to determine whether or not a federal undertaking would significantly affect the environment. If this is not the case, the agency issues a Finding of No Significant Impact (FONSI). An Environmental Impact Statement (EIS) is a more detailed evaluation of the proposed action and alternatives. A Notice of Intent (NOI) announces an agency's decision to prepare an EIS for a particular action and must be published in the Federal Register. The public, other federal agencies and outside parties may provide input into the preparation of an EIS and then comment on the draft EIS when it is completed. Following the Final EIS, the agency will prepare a Record of Decision (ROD).)

D.6. Property Descriptions

In contrast to right-of-way maps being internal documents, property descriptions are prepared as exhibits for the conveyance of property interests that will be affected. The property descriptions reflect a boundary survey and include metes and bounds descriptions, as well as parcel plat determinations. Property descriptions should be summarized from survey information into an appropriate documentation form that can be logged into project information systems. Information needed includes:

- ❑ Type of property or businesses affected
- ❑ Historical data used in preparing the survey
- ❑ Parcel plats
- ❑ Parcel size and area
- ❑ Control reference point data
- ❑ Centerline station ties
- ❑ Control of access lines
- ❑ County lines
- ❑ City limit lines
- ❑ Other

D.7. Ownership Determinations

Right-of-way ownership descriptions and title determinations should be produced and made available to complement draft schematics. Property ownership along the proposed routes can be determined in the following ways:

- ❑ Review of existing right-of-way maps from previous projects
- ❑ On-site canvas of the proposed affected properties
- ❑ Appraisal maps and records
- ❑ Abstractor's indices
- ❑ Real property records
- ❑ Other

D.8. Right-of-Way Mapping

A right-of-way map is a compilation of internal data, property descriptions (which includes field notes and parcel plats), appraisal information, and improvements related to the transportation project. Right-of-way maps are recognized as internal plans and management documents, with significant impact on the project development process. Preparation of these maps normally begins after obtaining schematic design approval. Issues to consider include:

- Parcel numbers and priority
- Existing site information:
    - Improvements within right-of-way
    - Utility locations
    - Record ownership data of adjacent properties
    - Existing boundaries and limits
    - Existing drainage channels and easements
- Design information:
    - Access control lines
    - Configuration of roadway
    - Hydraulics
    - Frontage roads
    - Connecting Ramps
- Parcel information:
    - Property owner name
    - Parcel title requirements
    - Parcel number
    - Parent tract
    - Type of conveyance, if known (e.g., donation, negotiation, condemnation)
    - Station to station limits and offset
    - Area in acres and/or square feet
    - Area of uneconomic remainders
    - Property lines
    - Bearing and distance to control points
    - Property descriptions
- Other

D.9. Constraints Mapping

Environmental constraints should be incorporated into preliminary right-of-way maps and schematics. This makes it easier to track the project alternatives across potential hazardous environmental locations. Issues to consider include:

- Landfill and superfund records
- Underground storage tank locations
- Wetlands identification
- Floodway identification
- Endangered species locations
- Public park space
- Cultural resources

- ❑ Historical landmarks
- ❑ Stockpiles and production sites
- ❑ Outfall locations
- ❑ Oil and gas well piping
- ❑ Poly-chlorinated biphenyls (PCB) transformers
- ❑ Other

D.10. Right-of-Way Site Issues

Certain issues may cause difficulties in right-of-way acquisition. These issues need to be identified for the proposed parcels and a determination should be made as to their impact. Issues to consider include:

- ❑ Hazardous material exposure
- ❑ Railroad interests
- ❑ Special use properties (e.g., government use, alcohol sales, cemeteries, pet cemeteries, etc.)
- ❑ Beautification and signage
- ❑ Land use impacts
- ❑ Socioeconomic impacts
- ❑ Economic development/speculation
- ❑ Legal (lawyer) activity in area
- ❑ Title curative issues
- ❑ Federal properties
- ❑ Number of partial takings
- ❑ Splitting of parcels
- ❑ Cultural issues
- ❑ Other

E. LOCATION & GEOMETRY

E.1. Horizontal & Vertical Alignment

Due to the near permanent nature of roadway alignment once a transportation facility is constructed, it is important that the proper alignment be selected considering design speed, existing and future roadside development, subsurface conditions, topography, etc. Issues to consider include:

- ❑ Curve radius
- ❑ Super-elevation
- ❑ Crossover grades and profiles
- ❑ Sight distances and roadway contours
- ❑ Other

E.2. Control of Access

Maintaining access to specific portions of the highway is developed with the preliminary design. Furthermore, the preliminary design needs to address the concerns of controlled access limits to and from adjacent property. Simultaneously, right-of-way personnel can look into access deeds and restrictions required for the proposed design. Issues to consider include:

- ❑ Entrance/exit locations and length
- ❑ Access deed restrictions
- ❑ Safety access and turnarounds
- ❑ Special required lanes:
    - ❑ Bike and pedestrian lanes
    - ❑ High Occupancy Vehicle (HOV)/High Occupancy Toll (HOT) lanes
    - ❑ Truck-only lanes
    - ❑ Crossover lanes
- ❑ Frontage road requirements
- ❑ Controlled access systems
- ❑ Split-parcel access requirements
- ❑ Driveway access requirements
- ❑ Other

E.3. Schematic Layouts

The submission of schematic layouts should include basic information necessary for the proper review and evaluation of the proposed improvement. The schematic is essential for use in public meetings and coordinating design features. Issues to consider include:

- ❑ General project information (e.g., boundary limits, speed, classification)
- ❑ Location of interchanges, main lanes, frontages, ramps
- ❑ Signing schematic
- ❑ Profiles and alignments
- ❑ Added capacity analysis
- ❑ Tentative right-of-way limits
- ❑ Geometrics
- ❑ Location of retaining and noise abatement walls
- ❑ Projected traffic volumes
- ❑ Control of access lines
- ❑ Interstate access justification
- ❑ Median location and width
- ❑ Auxiliary lanes
- ❑ Existing structures and removal of improvements
- ❑ Other

TxDOT Requirements:

- ❑ *Schematics must be approved by the Federal Highway Administration (FHWA) if involving Federal funding.*

E.4. Cross-Sectional Elements

Typical highway cross-sections are an important design element related to cost and schedule of the proposed project. The width of the right-of-way will be controlled by the proposed design. Examination of the typical cross-section will indicate those elements of design affecting the width of proposed right-of-way and utility adjustments among other factors. Issues to consider include:

- ❑ Pavement cross slopes
- ❑ Number and width of lanes
- ❑ Width of median
- ❑ Width of shoulder
- ❑ Cross drainage structures
- ❑ Horizontal clearances to obstructions
- ❑ Extent of side slopes and ditches
- ❑ Extent of berm area
- ❑ Frontage roads and ramp radii
- ❑ Sidewalks and pedestrian elements
- ❑ Noise abatement walls
- ❑ Other

F. STRUCTURES

F.1. Bridge Structure Elements

Bridge requirements along the extent of right-of-way for a project are often necessary. As a result, right-of-way requirements must take into account the impacts of bridge design on the affected corridor. Foundations and clearance requirements should be addressed along with the following:

- ❑ Bridge structure locations
- ❑ Safety tolerances:
    - ❑ Maximum height clearances
    - ❑ Maximum loads and capacities
    - ❑ Other
- ❑ Clear roadway width
- ❑ Utilities attached to bridge structures
- ❑ Turnarounds
- ❑ Access requirements
- ❑ Maintenance of right-of-way

- ❑ Retaining walls and abutments
- ❑ Vertical and horizontal alignment
- ❑ Other

F.2. Hydraulic Structures

In analyzing or designing drainage facilities, the investment of time, expense, concentration, and completeness should be influenced by the relative importance of the facility. Some of the basic components inherent in the design or analysis of any highway drainage facility include data, surveys of existing characteristics, estimates of future characteristics, engineering design criteria, discharge estimates, structure requirements and constraints, and receiving facilities. Issues to consider include:

- ❑ Open channels and outfall structures:
  - ❑ Right-of-way impact
  - ❑ Environmental impact
- ❑ Storm drain systems
- ❑ Culverts
- ❑ Irrigation controls
- ❑ Street cleaning requirements
- ❑ Special required easements
- ❑ Other

F.3. Miscellaneous Design Elements

In addition to typical roadway design elements, the following features may require design consideration and the acquisition of additional right-of-way. These items should be identified and listed. Items may include:

- ❑ Longitudinal barriers
- ❑ Fencing
- ❑ Noise abatement walls
- ❑ Historical markers
- ❑ Rest areas and stops
- ❑ Extended shoulders for service
- ❑ Truck weigh stations
- ❑ Hazardous material traps
- ❑ Pedestrian separations and ramps
- ❑ Parking
- ❑ Traffic control operations
- ❑ Signage, delineation, roadway markings
- ❑ Emergency median openings and widths
- ❑ Runaway vehicle lanes
- ❑ Truck and bus facilities
- ❑ Other

G. DESIGN PARAMETERS

G.1. Provisional Maintenance Requirements

Everything constructed or placed in the highway right-of-way must be maintained. This would include items such as roadway structures, drainage structures, traffic control devices, vegetation, and other highway related items. The roadway alignment and cross-sections should provide accommodation for maintenance equipment off the paved areas to service these items when necessary. Placement of utilities should be considered in terms of impact on maintenance. To the extent practical, utilization of desirable design criteria recommended regarding maximum roadway side-slope ratios and ditch profile grades will reduce maintenance and make required maintenance operation easier to accomplish. Items to consider include:

- ❑ Extent of berm areas
- ❑ Elevated and subsurface roadways
- ❑ Route accessibility
- ❑ Route detour options
- ❑ Retaining walls
- ❑ Technology support structures
- ❑ Access gates or ramps
- ❑ Surfaces finishes (paint, hot-dip galvanized, etc.)
- ❑ Types of vegetation
- ❑ Other

G.2. Constructability

Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Maximum benefits occur when people with construction knowledge and experience become involved at the very beginning of a project. A structured approach for constructability analysis should be in place. Provisions should be made to provide this on an ongoing basis. This would include examining design options and details of construction that minimize construction costs while maintaining standards of safety, quality, and schedule. Elements of constructability during advance planning include:

- ❑ Constructability program in existence
- ❑ Construction knowledge/experience used in project planning
- ❑ Early construction involvement in contracting strategy development
- ❑ Developing a construction-sensitive project schedule
- ❑ Developing site layouts for efficient construction
- ❑ Early identification of project team participants for constructability analysis
- ❑ Construction easements for right-of-way planning

- ❑ Usage of advanced information technologies
- ❑ Other

H. INSTALLED EQUIPMENT

H.1. Equipment List

Project-specific installed equipment should be defined and listed. Items may include:

- ❑ Electronic signage
- ❑ Highway traffic signals
- ❑ Temporary traffic control zone devices
- ❑ Traffic control devices:
    - ❑ Low-volume roads
    - ❑ For school areas
    - ❑ Highway-rail or transit grade crossings
    - ❑ Bicycles
    - ❑ Highway-light rail transit grade crossings
- ❑ Intelligent transportation systems devices:
    - ❑ Cameras
    - ❑ Loop detectors
    - ❑ Sensors
    - ❑ Monitors
- ❑ Rest area requirements
- ❑ Toll equipment
- ❑ Other

H.2. Equipment Location Drawings

Equipment location/arrangement preliminary drawings identify the location of each item of installed equipment in a project. Issues to consider include:

- ❑ Location, including coordinates
- ❑ Coordination of location among all equipment
- ❑ Setbacks
- ❑ Traffic interface
- ❑ Elevation views of equipment, if possible
- ❑ Visibility of equipment
- ❑ Structural or foundation requirements for equipment
- ❑ Other

H.3. Equipment Utility Requirements

This evaluation should consist of a tabulated list of utility requirements for all major installed equipment items, including:

- ❑ Power:
  - ❑ Hard line
  - ❑ Solar
- ❑ Water
- ❑ Sewage
- ❑ Communications
- ❑ Fuel
- ❑ Other

SECTION III – EXECUTION APPROACH

I. ACQUISITION STRATEGY

I.1. Long-Lead Parcel & Utility Adjustment Identification

Right-of-way acquisition and utility adjustment are always on the critical path of a highway project if they are one of the tasks required. It is important to identify and focus on all parcels, but especially those that might cause delay (as identified in element D.10.). A strategy must be developed to address these problematic parcels and/or utility adjustments. Issues to consider include:

- ❑ Prioritization of parcels for acquisition and utilities for adjustment
- ❑ Defining responsible party for parcel acquisition and utility adjustment
- ❑ Appraisal performance
- ❑ Title commitment review
- ❑ Relocation of displacees
- ❑ Abatement and removal of improvements
- ❑ Other

I.2. Long-Lead/Critical Equipment & Materials Identification

Installed equipment and material items with long lead times may impact the design and construction schedule. These items should be identified and tracked. A strategy should be developed to expedite these items if possible. Examples may include:

- ❑ Toll equipment
- ❑ Electronic information boards
- ❑ Bridge structural components
- ❑ Pre-cast elements
- ❑ Other

I.3. Local Public Agencies Utilities Contracts & Agreements

Contractual agreements with Local Public Agencies (LPA) participants may be required. The execution of contractual agreements establishes responsibilities for the acquisition of right of way, adjustment of utilities and cost sharing between the LPA(s) and the Department of Transportation (DOT). The type of contract to be used is determined by whether the LPA desires to administer right of way activities and payments or defer those responsibilities to the DOT. Issues to consider include:

- ❑ Cost participation and work responsibilities between the DOT and LPAs
- ❑ Prerequisites to secure right-of-way project release on non-federal-aid projects
- ❑ Request for determination of eligibility
- ❑ Other

TxDOT Requirements:

- ❑ *ROW-RM-37, Contractual Agreement for Right of Way Procurement*
- ❑ *ROW-RM-129, Agreement to Contribute Funds*

I.4. Utility Agreement & Joint-Use Contracts

Prioritizing utility agreements may be essential to insure that the concurrent review and approval processes are coordinated and efficient. The utility agreements and joint-use contracts effectively enable the utility to share space on public right-of-way and complete utility adjustments. Issues to consider include:

- ❑ Utility agreements, plans, and estimates
- ❑ Supporting documentation
- ❑ Transmittal memo from district to division
- ❑ Other

TxDOT Requirements:

- ❑ *Form ROW-U-1A, ROW-U-1B, or ROW-U-1C, appropriate property interest document*
- ❑ *Form ROW-U-48, statement covering contract work*
- ❑ *Form ROW-U-JUAA, Joint-use acknowledgement*
- ❑ *Form ROW-U-40, signature authority*
- ❑ *District and division approval processes*

I.5. Project Delivery Method & Contracting Strategies

The methods of project design and construction delivery, including fee structure should be identified. Types of project delivery methods and contract strategies to consider include:

- ❑ Owner self-performed
- ❑ Comprehensive development agreement (CDA) concession
- ❑ Designer and constructor qualification selection process
- ❑ Selected methods (e.g., design/build, construction management (CM) at risk, competitive sealed proposal, bridging, design-bid-build)
- ❑ Fee arrangement (e.g., lump sum, cost-plus, negotiated)
- ❑ Design/build scope package considerations
- ❑ Other

I.6. Design/Construction Plan & Approach

This is a documented plan identifying the specific approach to be used in designing and constructing the project. It should include items such as:

- ❑ Responsibility matrix
- ❑ Subcontracting strategy
- ❑ Work week plan/schedule
- ❑ Organizational structure
- ❑ Work Breakdown Structure (WBS)
- ❑ Sequencing with parcel acquisition
- ❑ Construction sequencing of events
- ❑ Site logistics plan
- ❑ Safety requirements/program
- ❑ Identification of critical activities that have potential impact on facilities (i.e., existing facilities, traffic flows, utility shut downs and tie-ins)
- ❑ Quality assurance/quality control (QA/QC) plan
- ❑ Design and approvals sequencing of events
- ❑ Integration of design, right-of-way acquisition, utility adjustment, and construction
- ❑ Equipment procurement and staging
- ❑ Contractor meeting/ reporting schedule
- ❑ Partnering or strategic alliances
- ❑ Alternative dispute resolution
- ❑ Furnishings, equipment, and built-ins responsibility
- ❑ Other

I.7. Procurement Procedures & Plans

Procurement procedures and plans include specific guidelines, special requirements, or methodologies for accomplishing the purchasing, expediting, and delivery of equipment and materials required for the project. Issues to consider include:

- ❑ The party performing procurement
- ❑ Listing of approved vendors, if applicable
- ❑ Client or contractor purchase orders
- ❑ Reimbursement terms and conditions
- ❑ Guidelines for supplier alliances, single source, or competitive bids
- ❑ Guidelines for engineering/construction contracts
- ❑ Responsibility for owner-purchased items, including:
    - ❑ Financial
    - ❑ Shop inspection
    - ❑ Expediting
- ❑ Tax strategy, including:
    - ❑ Depreciation capture
    - ❑ Local sales and use tax treatment
    - ❑ Investment tax credits
- ❑ Definition of source inspection requirements and responsibilities
- ❑ Definition of traffic/insurance responsibilities

- ❑ Definition of procurement status reporting requirements
- ❑ Additional/special owner accounting requirements
- ❑ Definition of spare parts requirements
- ❑ Local regulations (e.g., tax restrictions, tax advantages)
- ❑ Incentive/penalty strategy for contracts
- ❑ Storage
- ❑ Operating manual requirements and training
- ❑ Restricted distribution of construction documents for security and anti-terrorism reasons
- ❑ Other

I.8. Appraisal Requirements

Acquisition cannot begin until a formal right-of-way release is obtained. An early step in acquisition is to determine the value of parcels for reimbursement. Ensuring appraisal occurs in a timely manner is essential. Appraisal requirements include:

- ❑ Pre-appraisal contacts
- ❑ Determination of number of appraisers required
- ❑ Determination of appraisal assignments
- ❑ Use of contract appraisers
- ❑ Prioritization of parcel appraisals, if required
- ❑ Other

I.9. Advance Acquisition Requirements

Advance acquisition is defined as right-of-way acquisition that occurs before normal release for acquiring right-of-way is given on a transportation project. Advance acquisition requirements need to be identified and addressed as soon as possible in the project. Although this process bypasses detailed environmental scoping, consideration for environmental effects should be made in determining parcels for advance acquisition. Examples of advance acquisition include the following:

- ❑ Hardship acquisition of a parcel at the property owner's request
- ❑ Protective buying to prevent imminent parcel development that would materially increase right of way costs
- ❑ Donation of land for right-of-way purposes for no consideration
- ❑ Other

J. DELIVERABLES

J.1. CADD/Model Requirements

Computer Aided Drafting and Design (CADD) requirements should be defined. Evaluation criteria should include:

- ❑ Application software preference (e.g., 2D or 3D CADD, application service provider (ASP)), including licensing requirements
- ❑ Geographical Information System (GIS) requirements
- ❑ Configuration and administration of servers and systems documentation defined
- ❑ Compatibility requirements of information systems (e.g. design information system, construction information system)
- ❑ Owner/contractor standard symbols, file formats and details
- ❑ Handling of life cycle facility data including asset information, models, and electronic documents
- ❑ Information technology infrastructure to support electronic modeling systems, including uninterruptible power systems (UPS) and disaster recovery
- ❑ Security and auditing requirements defined
- ❑ Physical model requirements
- ❑ Other

TxDOT Requirements:

- ❑ *Use of Microstation in design*
- ❑ *Use of Statewide TxDOT Computer-Aided Drawing (CAD) Standard Plan Files (e.g, Bridge, Maintenance, Roadway, Traffic Standards)*
- ❑ *TxDOT Geopak Data Files*

J.2. Documentation/Deliverables

The following items should be included in a list of deliverables:

- ❑ Field surveying books
- ❑ Estimates
- ❑ Required submissions and/or approvals
- ❑ Drawings
- ❑ Project correspondence
- ❑ Permits
- ❑ Project data books (quantity, format, contents, and completion date)
- ❑ Equipment folders (quantity, format, contents, and completion date)
- ❑ Design calculations (quantity, format, contents, and completion date)
- ❑ Procuring documents
- ❑ As-built documents
- ❑ Quality assurance documents
- ❑ Updated information systems and databases
- ❑ Other

TxDOT Requirements:

- ❑ *Updated Design and Construction Information System (DCIS)*
- ❑ *Updated Financial Information Management Systems (FIMS)*

- ❑ *Updated Right of Way Information System (ROWIS)*
- ❑ *PS&E Submission:*
  - ❑ *PS&E Submission Data Sheet*
  - ❑ *Supporting Papers Checklists (e.g. ROW and utilities certificates, review plans prints, contract time determination summary)*
  - ❑ *PS&E Checklists (pre-submission checklist and PS&E checklist for either district review projects or division review projects)*

K. PROJECT CONTROL

K.1. Right-of-Way & Utilities Cost Estimates

The cost estimates will be prepared by the utility and submitted in support of the utility agreement and plans required for the proposed work. An agreement assembly should include estimates covering only the work for clearing transportation project construction. Right-of-way costs are defined as those instances where there is an interest in land acquired. Replacement right-of-way may be defined as the land and interests in land acquired outside existing highway right-of-way for or by the utility. Right-of-way costs incurred by a utility before issuance of the right-of-way project release may not be eligible for reimbursement. Right-of-way costs incurred after release may be reimbursed, if otherwise found eligible. Issues to consider include:

- ❑ Cost of right-of-way
- ❑ Cost of utility adjustment
- ❑ Salaries and expenses of utility employees engaged in the valuation and negotiation
- ❑ Amounts paid to independent fee appraisers for appraisal of the right-of-way
- ❑ Recording costs
- ❑ Deed fees
- ❑ Costs normally paid that are incidental to land acquisition
- ❑ Payment of property damages and losses to improvements
- ❑ Other

K.2. Design & Construction Cost Estimates

The project cost estimates should address all costs (excluding right-of-way acquisition and utility adjustment costs that are addressed in element K.1.) necessary for completion of the project. These cost estimates may include the following:

- ❑ Construction contract estimate
- ❑ Professional fees
- ❑ Administrative costs
- ❑ Contingencies
- ❑ Cost escalation for elements outside the project cost estimates
- ❑ Startup costs including installation

- ❑ Capitalized overhead
- ❑ Safety items
- ❑ Site-specific insurance requirements
- ❑ Incentives
- ❑ Miscellaneous expenses including but not limited to:
  - ❑ Specialty consultants
  - ❑ Inspection and testing services
  - ❑ Bidding costs
  - ❑ Site clearance
  - ❑ Environmental impact mitigation measures
  - ❑ Local authority permit fees
  - ❑ Sureties
- ❑ Taxes:
  - ❑ Depreciation schedule
  - ❑ Capitalized/expensed
  - ❑ Tax incentives
  - ❑ Contractors' sales tax
- ❑ Utility costs during construction (if paid by owner)
- ❑ Interest on borrowed funds (cost of money)
- ❑ Site surveys, soils tests
- ❑ Availability of construction laydown and storage at site or in remote or rented facilities
- ❑ Other

K.3. Project Cost Control

Procedures for controlling project cost need to be outlined and responsibility assigned. These may include cost control requirements such as:

- ❑ Financial (client/regulatory)
- ❑ Phasing or area sub-accounting
- ❑ Capital versus non-capital expenditures
- ❑ Report requirements
- ❑ Payment schedules and procedures
- ❑ Cash flow projections/draw down analysis
- ❑ Cost code scheme/strategy
- ❑ Costs for each project phase
- ❑ Periodic control check estimates
- ❑ Change order management procedure, including scope control and interface with information systems
- ❑ Costs pertaining to right-of-way acquisition and utility adjustment during project execution
- ❑ Other

K.4. Project Schedule Control

The project schedule is created to show progress and ensure that the project is completed on time. The schedule is necessary for design and construction of the facility. A schedule format should be decided on at the beginning of the project. Typical items included in a project schedule are listed below:

- ❑ Milestones
- ❑ Required submissions and/or approvals
- ❑ Required documentation/responsible party
- ❑ Baseline schedule versus progress-to-date schedule
- ❑ Critical path activities, including field surveys
- ❑ Contingency or "float time"
- ❑ Permitting or regulatory approvals
- ❑ Activation and commissioning
- ❑ Liquidated damages/incentives
- ❑ Unusual schedule considerations
- ❑ The owner must also identify how special project issues will be scheduled. These items may include:
  - ❑ Selection, procurement, and installation of equipment
  - ❑ Stages of the project that must be handled differently than the rest of the project
  - ❑ Tie-ins, service interruptions, and road closures
- ❑ Other

K.5. Project Quality Assurance & Control

Quality assurance and quality control procedures need to be established. Responsibility for approvals needs to be developed. Electronic media requirements should be outlined. These issues may include:

- ❑ Administration of contracted professional services
- ❑ Responsibility during design and construction
- ❑ Testing of materials and workmanship
- ❑ Quality management system requirements (e.g. ISO 9000)
- ❑ Environmental quality control
- ❑ Submittals
- ❑ Inspection reporting requirements
- ❑ Progress photos
- ❑ Reviewing changes and modifications
- ❑ Communication documents (e.g., Requests for Information, Requests for Qualifications)
- ❑ Lessons-learned feedback
- ❑ Other

U.S. Requirements:

- ❑ *Environmental quality control as outlined in U. S. National Environmental Policy Act (NEPA)*

TxDOT Requirements:

- ❑ *Administration of contracted Right of Way Acquisition Professional Services (ROWAPS)*

K.6. Safety Procedures

Safety procedures and responsibilities must be identified for design consideration and construction. Safety issues to be addressed may include:

- ❑ Staging area for material handling
- ❑ Environmental safety procedures, including hazardous material handling
- ❑ Right-of-way needs for safe construction
- ❑ Right-of-way requirements for design safety
- ❑ Safety in utility adjustment
- ❑ Interaction with the public
- ❑ Working at elevations/fall hazards
- ❑ Evacuation plans and procedures
- ❑ Drug testing
- ❑ First aid stations
- ❑ Accident reporting and investigation
- ❑ Pre-task planning
- ❑ Safety for motorists
- ❑ Safety orientation and planning
- ❑ Safety incentives
- ❑ Contractor requirements
- ❑ Other special or unusual safety issues

L. PROJECT EXECUTION PLAN

L.1. Environmental Commitments & Mitigation

Environmental commitments determine what a project's involved parties can and cannot do to protect the environment. Environmental commitments begin at the earliest phase of project development, although completion of commitments may not occur until the operation and maintenance phase of a project. Because there is a substantial time gap between the beginning and end of a commitment, it is imperative that commitments are communicated from environmental clearance through detailed design, pre-bid conference, project letting, maintenance, and operation. Issues to consider include:

- ❑ Avoidance commitments
- ❑ Compensation commitments
- ❑ Enhancements commitments
- ❑ Minimization commitments
- ❑ Habitat mitigation
- ❑ Water quality facilities management
- ❑ Wetland mitigation
- ❑ Storm water management plans
- ❑ Cultural resources mitigation
- ❑ Noise abatement remediation
- ❑ Hazardous materials abatement locations
- ❑ Environmental remediation plans
- ❑ Other

L.2. Interagency Coordination

Early coordination with appropriate resource agencies, local governmental entities, and the public plays a vital role in project planning and environmental development of proposed projects. Both the districts and divisions are responsible for interagency coordination during project planning and development. Coordination is initiated at the regional and statewide levels. Coordination agencies to consider may include:

- ❑ State historic preservation offices
- ❑ Natural resource conservation services
- ❑ Environmental protection agencies
- ❑ Fish and wildlife services
- ❑ International boundary and water commissions
- ❑ Federal emergency management agencies
- ❑ Offices of habitat conservation
- ❑ Law enforcement agencies
- ❑ Immigration agencies
- ❑ Parks and wildlife agencies
- ❑ Other

U.S. & TxDOT-Related Agency Coordination:

- ❑ *Metropolitan Planning Organization (MPO)*
- ❑ *Texas Commission on Environmental Quality (TCEQ)*
- ❑ *Coastal Coordination Council (CCC)*
- ❑ *Environmental Protection Agency (EPA)*
- ❑ *Federal Emergency Management Agency (FEMA)*

L.3. Local Public Agency Contractual Agreements

To establish acquisition and funding responsibilities and requirements of the Department of Transportation (DOT) and a Local Public Agency (LPA), an agreement must be entered into before a project is released for right-of-way acquisition. Issues to consider include:

- ❑ Master agreement governing local transportation project advance funding agreements
- ❑ Reimbursement to the LPA for negotiated parcels
- ❑ Local project advance funding agreement
- ❑ Other

TxDOT Requirements:

- ❑ *Master Advance Funding Agreement (MAFA)*
- ❑ *Local Public Agency Funding Agreement (LPAFA)*

L.4. Interagency Joint-Use Agreements

There are various agencies, districts, and commercial interests that the Department of Transportation must execute agreements with in order to jointly use certain right-of-ways or for utility adjustments. Joint-use agreements may include:

- ❑ Railroad agencies
- ❑ Flood control district
- ❑ Utility companies
- ❑ Municipal utility districts (MUDs)
- ❑ Roadway utility districts (RUDs)
- ❑ Other

U.S. joint-use agreements may include:

- ❑ *Corps of Engineers*

L.5. Preliminary Traffic Control Plan

Traffic control plans should clearly show provisions for safe and efficient operation of all modes of transportation during construction and safety of construction workers and inspection personnel. A preliminary traffic control plan that is compliant with the U. S. and state Department of Transportation Manual of Uniform Traffic Control Devices (MUTCD) should be developed. Issues to consider include:

- ❑ A detour plan
- ❑ Appropriate signs, markings, and barricades per the traffic control plan
- ❑ Safety equipment, such as:
  - ❑ Barrels
  - ❑ Signage

    - ❑ Flagmen
    - ❑ Positive barriers
    - ❑ Vertical panels
- ❑ Clear zone protection devices, such as:
    - ❑ Concrete traffic barriers
    - ❑ Metal beam guard fencing
    - ❑ Appropriate end treatments
    - ❑ Other appropriate warning devices
- ❑ Other

L.6. Substantial Completion Requirements

Substantial Completion (SC) is the point in time when the facilities are ready to be used for their intended purposes. Preliminary requirements for substantial completion need to be determined to assist the planning and design efforts. The following may need to be addressed:

- ❑ Specific requirements for SC responsibilities developed and documented
- ❑ Warranty, permitting, insurance, and tax implication considerations
- ❑ Commissioning
- ❑ Technology start-up support on-site, including information technology and systems
- ❑ Equipment/systems startup and testing
- ❑ Occupancy phasing
- ❑ Final code inspection
- ❑ Calibration
- ❑ Verification
- ❑ Documentation
- ❑ Training requirements for all systems
- ❑ Community acceptance
- ❑ Landscape requirements
- ❑ Punchlist completion plan and schedule
- ❑ Substantial completion certificate
- ❑ Other

Appendix 3. Select Weighting Workshop Documents

A WORKSHOP AGENDA EXAMPLE

TXDOT RESEARCH PROJECT 0-5478

APRA Weighting Workshop Meeting Agenda

MEETING DETAILS:

Date: September 13, 2006

Time: 9:30 AM – 3:00 PM (CST)

Location: Dallas District Office
4777 US Highway 80 East
Mesquite, TX 75149

Re: Advance Planning Risk Analysis

TOPICS OF DISCUSSION:

I. Introductions & Background Information *(9:30 – 10:00 am)* – GEG

II. Weighting Input to the APRA *(10:00 – 11:30 am)* – GEG

III. Lunch – Provided by CTR *(11:30 – 12:30 pm)*

IV. Weighting Input to the APRA – continued *(12:30 – 2:30 pm)* – CHC

V. Final Discussion on APRA *(2:30 – 3:00 pm)* – GEG, CHC

BRIEF INTRODUCTION TO THE APRA

TxDOT Research Project 0-5478 Team is developing the **Advance Planning Risk Analysis (APRA)** as a best practices tool for improving the effectiveness of the project development process on **transportation projects**. The APRA is envisioned to help the project development team to improve the process through structured yet flexible risk management, which consists of identifying, analyzing, and controlling risk issues. Fifty-nine risk issues have been identified by the research project team. Upon completion, the tool can be used to rate a project and yield a score and generate a list of issues to be addressed. The score and the list can be used to evaluate riskiness of the project, the project's chance for success, and the areas that the project team needs to address.

As stated above, fifty nine risk issues have been identified and grouped into categories and sections. However, we understand that they are not equally important regarding to the impact on the project's success. We are asking that experienced project managers and project development subject experts help us determine the issues' impact on overall project success. For this, we sincerely request your assistance. We believe that your skills and experience will be invaluable in helping us determine **weighting factors** that should be assigned to each issue.

Again, we appreciate any assistance you can provide in developing the APRA. We believe this tool to be a valuable resource for improving advance planning efforts on transportation projects. Once it is complete, we will provide you with a copy for your use. We plan to have a completed version ready fall 2007.

Thank you very much for your time and effort.

INSTRUCTIONS FOR EVALUATING THE APRA ELEMENTS

Who should evaluate the APRA?

The APRA consists of three sections:

- Section I: Basis of Project Decision
- Section II: Basis of Design
- Section III: Execution Approach

As stated in the Brief Introduction to the APRA, those with experience in both *project management* and the *project development process* should complete the APRA Weighting Factor Evaluation form. This approach will provide the research team with the most accurate evaluation of the APRA element weights and allow us to assess the relative importance of each element.

How to evaluate the APRA?

Evaluate each element in the following manner:

> Assume that your team is estimating a typical project that your organization works on and evaluating its probability of success based on the 59 criteria defined in the APRA Descriptions document. (When performing this evaluation, please consider a typical project type and size familiar to you. Please state the type of project as well as its total installed dollar value in the Background Information sheet.) Evaluate the *level of definition* of each element in the APRA Element Descriptions and apply what you feel to be an appropriate **contingency** to that element **(i.e., its individual impact on Total Installed Cost stated as a percentage of the overall estimate at the point where detailed design is about to commence)**. In other words, what contingency would you deem appropriate for an element when evaluating its current level of definition considering that you were about to begin the development of PS&E (plans, specifications, and estimates), i.e. after environmental clearance and ROW release. An element's level of definition has impact on both cost and time aspects of a project. Thus, when determining the level of contingency to apply, take both cost and time (converted into cost) impacts into consideration. The levels of definition that will be used for evaluating each element are 1 and 5 and are defined as follows:

1 = Complete Definition

5 = Incomplete or Poor Definition

As an element becomes more well-defined, assess how this would affect the percentage of contingency that you would allocate for it when planning the project. For example, if you were developing an estimate for a new highway construction project, how would the level of definition of the "Right-of-Way Mapping" in the project definition package affect your estimate? What contingency would you deem appropriate for the "Right-of-Way Mapping" that were well defined and totally undefined.

Our recommended methodology:

Consider each element *individually*. Evaluate the worst case scenario first. If that element is incomplete or poorly defined (i.e., level 5), assess what percent contingency you would deem appropriate for that element and write it on the evaluation form in the corresponding box. As shown in the following example, you may feel that 30 percent is appropriate for this element. Then, evaluate the best case scenario assuming that the element is perfectly defined (i.e., level 1), and apply a contingency in a similar fashion. This contingency should be a low number, perhaps 2 percent.

Example:

CATEGORY Element	**Definition Level**				
	1	**2**	**3**	**4**	**5**
D. SITE INFORMATION					
D8. Right-of-Way Mapping	2%				30%

Definition Levels: 1 = Complete Definition 5 = Incomplete or Poor Definition

Also enclosed is a Background Information sheet. We ask that you please take a few moments to complete this form. The research team needs to thoroughly document all sources used to create the APRA to ensure its acceptance by the user. Further, we have enclosed a Suggestions for Improvement sheet with which you may evaluate any item in this package. We gladly welcome your opinions and sincerely request any feedback regarding items that may be unclear, redundant, unnecessary, or left out. We will discuss these issues at the close of the workshop.

Thank you very much for your time and effort. If you have any questions, please contact:

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BACKGROUND INFORMATION

<table>
<tr><td>Name:</td><td>Date:</td></tr>
<tr><td colspan="2">Employer:</td></tr>
<tr><td colspan="2">Working Position:</td></tr>
<tr><td colspan="2">Department/Division:</td></tr>
<tr><td>Working Address:</td><td>Alternate Address:</td></tr>
<tr><td>Phone: ( )</td><td>Phone: ( )</td></tr>
<tr><td>Fax: ( )</td><td>Fax: ( )</td></tr>
<tr><td colspan="2">Email address:</td></tr>
<tr><td colspan="2">Project Management/Project Development Experience</td></tr>
<tr><td colspan="2">1) Total years of PM/PD experience:</td></tr>
<tr><td colspan="2">2) What percentage of your experience was spent on the following types of projects:
• Urban? • Rural?
• Other (what types)?</td></tr>
<tr><td colspan="2">3) Average annual dollar value of projects worked on or estimated over the last 3 years?</td></tr>
<tr><td colspan="2">4) What percentage of your experience was spent on the following types of projects:
• New construction? • Renovations/Expansion?</td></tr>
<tr><td colspan="2">5) During your career, what is the approximate total value of your projects involving...
• New construction? • Renovations/Expansion?</td></tr>
<tr><td colspan="2">Typical Project for Your Organization and Your Basis for APRA Weighting</td></tr>
<tr><td colspan="2">1) What type of projects, typical for your company, was used as a basis for weighting the APRA? (please choose one)
❑ New, Urban ❑ New, Rural
❑ Renovations/Expansion, Urban ❑ Renovations/Expansion, Rural</td></tr>
</table>

2) What was the total installed dollar value of the project considered? (*please choose one*) ❑ Less than $5 million ❑ $5 to $10 million ❑ $10 to $20 million ❑ $20 to $50 million ❑ $50 to $100 million ❑ Over $100 million
3) Write down the name and size of the project. (i.e., ABC Highway, 10 miles)
4) Using a scale of 1 to 5, please rate how successful you feel that this project was (circle only one): 1 2 3 4 5 very unsuccessful ========================> very successful

APRA WEIGHTING FACTOR EVALUATION FORM

ADVANCE PLANNING RISK ANALYSIS (APRA)
FOR TRANSPORTATION PROJECTS

Name: ___________________________________ Date:

SECTION I – BASIS OF PROJECT DECISION						
CATEGORY Element	**Definition Level**					**Comments**
	1	**2**	**3**	**4**	**5**	
A. PROJECT STRATEGY						
A1. Need & Purpose Documentation						
A2. Investment Studies & Alternatives Assessments						
A3. Programming & Funding Data						
A4. Key Team Member Coordination						
A5. Public Involvement						

Definition Levels: 1 = Complete Definition 5 = Incomplete or Poor Definition

B. OWNER/OPERATOR PHILOSOPHIES						
B1. Design Philosophy						
B2. Operating Philosophy						
B3. Maintenance Philosophy						
B4. Future Expansion & Alteration Considerations						
C. PROJECT REQUIREMENTS						
C1. Functional Classification & Use						
C2. Evaluation of Compliance Requirements						
C3. Survey of Existing Environmental Conditions						
C4. Determination of Utility Impacts						
C5. Value Engineering						

Definition Levels: 1 = Complete Definition 5 = Incomplete or Poor Definition

SECTION II – BASIS OF DESIGN						
CATEGORY Element	**Definition Level**					**Comments**
	1	**2**	**3**	**4**	**5**	
D. SITE INFORMATION						
D1. Geotechnical Characteristics						
D2. Hydrological Characteristics						
D3. Surveys & Planimetrics						
D4. Permitting Requirements						
D5. Environmental Documentation						
D6. Property Descriptions						
D7. Ownership Determinations						
D8. Right-of-Way Mapping						
D9. Constraints Mapping						
D10. Right-of-Way Site Issues						
E. LOCATION & GEOMETRY						
E1. Horizontal & Vertical Alignment						

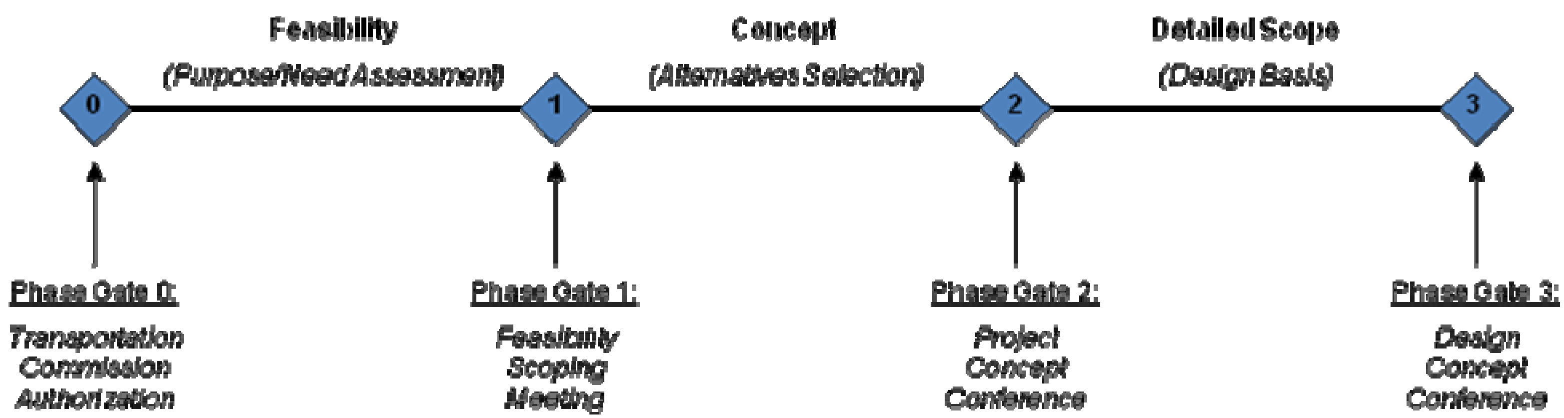
E2.	Control of Access						
E3.	Schematic Layouts						
E4.	Cross-Sectional Elements						
F. STRUCTURES							
F1.	Bridge Structure Elements						
F2.	Hydraulic Structures						
F3.	Miscellaneous Design Elements						
G. DESIGN PARAMETERS							
G1.	Provisional Maintenance Requirements						
G2.	Constructability						
H. INSTALLED EQUIPMENT							
H1.	Equipment List						
H2.	Equipment Location Drawings						
H3.	Equipment Utility Requirements						

Definition Levels: 1 = Complete Definition 5 = Incomplete or Poor Definition

SECTION III – EXECUTION APPROACH						
CATEGORY Element	**Definition Level**					**Comments**
	1	**2**	**3**	**4**	**5**	
I. ACQUISITION STRATEGY						
I1. Long-Lead Parcel & Utility Adjustment Identification						
I2. Long-Lead/Critical Equipment & Materials Identification						
I3. Local Public Agencies Utilities Contracts & Agreements						
I4. Utility Agreement & Joint-Use Contracts						
I5. Project Delivery Method & Contracting Strategies						
I6. Design/Construction Plan & Approach						
I7. Procurement Procedures & Plans						
I8. Appraisal Requirements						
I9. Advance Acquisition Requirements						
J. DELIVERABLES						
J1. CADD/Model Requirements						

J2.	Documentation/Deliverables						
K. PROJECT CONTROL							
K1.	Right-of-Way & Utilities Cost Estimates						
K2.	Design & Construction Cost Estimates						
K3.	Project Cost Control						
K4.	Project Schedule Control						
K5.	Project Quality Assurance & Control						
K6.	Safety Procedures						
L. PROJECT EXECUTION PLAN							
L1.	Environmental Commitments & Mitigation						
L2.	Interagency Coordination						
L3.	Local Public Agency Contractual Agreements						
L4.	Interagency Joint-Use Agreements						
L5.	Preliminary Traffic Control Plan						
L6.	Substantial Completion Requirements						

Preliminary Flowchart of Key Stages
Prior to Right-of-Way Release & Detailed Design



Appendix 4. Normalization Example for a Workshop Participant's Scores

Elmnt	Original Weight		Nrmlized Weight		Elmnt	Original Weight		Nrmlized Weight	
	Level 1	Level 5	Level 1	Level 5		Level 1	Level 5	Level 1	Level 5
A1	3	30	2.7	26.5	F3	2	20	1.8	17.7
A2	4	35	3.5	31.0	G1	1	5	0.9	4.4
A3	10	50	8.8	44.2	G2	2	25	1.8	22.1
A4	5	40	4.4	35.4	H1	1	5	0.9	4.4
A5	4	35	3.5	31.0	H2	1	5	0.9	4.4
B1	2	15	1.8	13.3	H3	2	10	1.8	8.8
B2	2	20	1.8	17.7	I1	4	40	3.5	35.4
B3	2	20	1.8	17.7	I2	1	5	0.9	4.4
B4	3	25	2.7	22.1	I3	5	50	4.4	44.2
C1	1	10	0.9	8.8	I4	4	40	3.5	35.4
C2	1	10	0.9	8.8	I5	2	15	1.8	13.3
C3	1	15	0.9	13.3	I6	2	25	1.8	22.1
C4	5	40	4.4	35.4	I7	2	20	1.8	17.7
C5	2	20	1.8	17.7	I8	1	5	0.9	4.4
D1	1	10	0.9	8.8	I9	N/A	N/A	N/A	N/A
D2	4	35	3.5	31.0	J1	0	5	0.0	4.4
D3	3	25	2.7	22.1	J2	1	10	0.9	8.8
D4	1	10	0.9	8.8	K1	4	45	3.5	39.8
D5	2	25	1.8	22.1	K2	2	20	1.8	17.7
D6	3	25	2.7	22.1	K3	1	10	0.9	8.8
D7	3	25	2.7	22.1	K4	3	25	2.7	22.1
D8	3	25	2.7	22.1	K5	2	10	1.8	8.8
D9	1	15	0.9	13.3	K6	1	5	0.9	4.4
D10	2	25	1.8	22.1	L1	1	5	0.9	4.4
E1	3	35	2.7	31.0	L2	1	5	0.9	4.4
E2	1	10	0.9	8.8	L3	1	5	0.9	4.4
E3	2	20	1.8	17.7	L4	1	5	0.9	4.4
E4	1	10	0.9	8.8	L5	1	5	0.9	4.4
F1	2	20	1.8	17.7	L6	1	5	0.9	4.4
F2	2	20	1.8	17.7	$\sum$		**1130**	**114**	**1000**

Total of Level 5 Scores **1130**

Multiplier **0.885**

Total of Level 5 Normalized Scores **1000**

Total of Level 1 Normalized Scores **114**

Appendix 5. APRA Element Weights after Linear Interpolation

Element	Definition Level					Element	Definition Level				
	1	2	3	4	5		1	2	3	4	5
A1	1	7	12	18	23	F3	1	4	8	11	14
A2	2	8	14	19	25	G1	1	4	6	9	11
A3	2	9	16	23	30	G2	1	5	10	14	18
A4	1	6	11	16	21	H1	1	3	5	7	9
A5	2	7	13	18	23	H2	1	3	5	6	8
B1	1	7	12	18	23	H3	1	4	7	10	13
B2	1	5	10	14	18	I1	2	8	13	19	24
B3	1	5	9	12	16	I2	1	4	7	9	12
B4	2	6	11	15	19	I3	1	6	10	15	19
C1	1	5	8	12	15	I4	1	6	11	15	20
C2	1	6	10	15	19	I5	1	4	7	10	13
C3	2	8	14	20	26	I6	1	4	8	11	14
C4	2	9	16	23	30	I7	1	3	6	8	10
C5	1	4	7	9	12	I8	1	4	8	11	14
D1	1	5	9	12	16	I9	1	4	6	9	11
D2	1	5	10	14	18	J1	1	3	6	8	10
D3	1	5	10	14	18	J2	1	4	7	10	13
D4	1	5	9	13	17	K1	2	7	12	16	21
D5	2	7	12	17	22	K2	2	7	12	16	21
D6	1	5	8	12	15	K3	1	5	9	13	17
D7	1	4	7	10	13	K4	1	5	9	12	16
D8	1	5	9	12	16	K5	1	3	6	8	10
D9	1	6	10	15	19	K6	1	4	7	10	13
D10	1	6	10	15	19	L1	1	5	8	12	15
E1	1	6	11	15	20	L2	1	5	8	12	15
E2	1	5	9	13	17	L3	1	5	8	12	15
E3	2	8	13	19	24	L4	1	4	8	11	14
E4	1	5	10	14	18	L5	1	4	7	10	13
F1	1	5	9	12	16	L6	1	4	6	9	11
F2	1	5	10	14	18						
						TOTAL	**70**	**310**	**549**	**776**	**1000**

Appendix 6. APRA Weighted Project Score Sheets

SECTION I - BASIS OF PROJECT DECISION							
CATEGORY Element	**Definition Level**						**Score**
	0	**1**	**2**	**3**	**4**	**5**	
A. PROJECT STRATEGY (Maximum = 122)							
A1. Need & Purpose Documentation	0	1	7	12	18	23	
A2. Investment Studies & Alternatives Assessments	0	2	8	14	19	25	
A3. Programming & Funding Data	0	2	9	16	23	30	
A4. Key Team Member Coordination	0	1	6	11	16	21	
A5. Public Involvement	0	2	7	13	18	23	
CATEGORY A TOTAL							
B. OWNER/OPERATOR PHILOSOPHIES (Maximum = 76)							
B1. Design Philosophy	0	1	7	12	18	23	
B2. Operating Philosophy	0	1	5	10	14	18	
B3. Maintenance Philosophy	0	1	5	9	12	16	
B4. Future Expansion & Alteration Considerations	0	2	6	11	15	19	
CATEGORY B TOTAL							
C. PROJECT REQUIREMENTS (Maximum = 102)							
C1. Functional Classification & Use	0	1	5	8	12	15	
C2. Evaluation of Compliance Requirements	0	1	6	10	15	19	
C3. Survey of Existing Environmental Conditions	0	2	8	14	20	26	
C4. Determination of Utility Impacts	0	2	9	16	23	30	
C5. Value Engineering	0	1	4	7	9	12	
CATEGORY C TOTAL							
Section I Maximum Score = 300 SECTION I TOTAL							

Definition Levels

0 = Not Applicable	2 = Minor Deficiencies	4 = Major Deficiencies
1 = Complete Definition	3 = Some Deficiencies	5 = Incomplete or Poor Definition

SECTION II - BASIS OF DESIGN							
CATEGORY Element	**Definition Level**						**Score**
	0	**1**	**2**	**3**	**4**	**5**	
D. SITE INFORMATION (Maximum = 173)							
D1. Geotechnical Characteristics	0	1	5	9	12	16	
D2. Hydrological Characteristics	0	1	5	10	14	18	
D3. Surveys & Planimetrics	0	1	5	10	14	18	
D4. Permitting Requirements	0	1	5	9	13	17	
D5. Environmental Documentation	0	2	7	12	17	22	
D6. Property Descriptions	0	1	5	8	12	15	
D7. Ownership Determinations	0	1	4	7	10	13	
D8. Right-of-Way Mapping	0	1	5	9	12	16	
D9. Constraints Mapping	0	1	6	10	15	19	
D10. Right-of-Way Site Issues	0	1	6	10	15	19	
CATEGORY D TOTAL							
E. LOCATION & GEOMETRY (Maximum = 79)							
E1. Horizontal & Vertical Alignment	0	1	6	11	15	20	
E2. Control of Access	0	1	5	9	13	17	
E3. Schematic Layouts	0	2	8	13	19	24	
E4. Cross-Sectional Elements	0	1	5	10	14	18	
CATEGORY E TOTAL							
F. STRUCTURES (Maximum = 48)							
F1. Bridge Structure Elements	0	1	5	9	12	16	
F2. Hydraulic Structures	0	1	5	10	14	18	
F3. Miscellaneous Design Elements	0	1	4	8	11	14	
CATEGORY F TOTAL							
G. DESIGN PARAMETERS (Maximum = 29)							
G1. Provisional Maintenance Requirements	0	1	4	6	9	11	
G2. Constructability	0	1	5	10	14	18	
CATEGORY G TOTAL							
H. INSTALLED EQUIPMENT (Maximum = 30)							
H1. Equipment List	0	1	3	5	7	9	
H2. Equipment Location Drawings	0	1	3	5	6	8	
H3. Equipment Utility Requirements	0	1	4	7	10	13	
CATEGORY H TOTAL							
Section II Maximum Score = 359 SECTION II TOTAL							

SECTION III - EXECUTION APPROACH								
CATEGORY Element		**Definition Level**						**Score**
		0	**1**	**2**	**3**	**4**	**5**	
I. ACQUISITION STRATEGY (Maximum = 137)								
I1.	Long-Lead Parcel & Utility Adjustment Identification	0	2	8	13	19	24	
I2.	Long-Lead/Critical Equipment & Materials Identification	0	1	4	7	9	12	
I3.	Local Public Agencies Utilities Contracts & Agreements	0	1	6	10	15	19	
I4.	Utility Agreement & Joint-Use Contracts	0	1	6	11	15	20	
I5.	Project Delivery Method & Contracting Strategies	0	1	4	7	10	13	
I6.	Design/Construction Plan & Approach	0	1	4	8	11	14	
I7.	Procurement Procedures & Plans	0	1	3	6	8	10	
I8.	Appraisal Requirements	0	1	4	8	11	14	
I9.	Advance Acquisition Requirements	0	1	4	6	9	11	
							CATEGORY I TOTAL	
J. DELIVERABLES (Maximum = 23)								
J1.	CADD/Model Requirements	0	1	3	6	8	10	
J2.	Documentation/Deliverables	0	1	4	7	10	13	
							CATEGORY J TOTAL	
K. PROJECT CONTROL (Maximum = 98)								
K1.	Right-of-Way & Utilities Cost Estimates	0	2	7	12	16	21	
K2.	Design & Construction Cost Estimates	0	2	7	12	16	21	
K3.	Project Cost Control	0	1	5	9	13	17	
K4.	Project Schedule Control	0	1	5	9	12	16	
K5.	Project Quality Assurance & Control	0	1	3	6	8	10	
K6.	Safety Procedures	0	1	4	7	10	13	
							CATEGORY K TOTAL	
L. PROJECT EXECUTION PLAN (Maximum = 83)								
L1.	Environmental Commitments & Mitigation	0	1	5	8	12	15	
L2.	Interagency Coordination	0	1	5	8	12	15	
L3.	Local Public Agency Contractual Agreements	0	1	5	8	12	15	
L4.	Interagency Joint-Use Agreements	0	1	4	8	11	14	
L5.	Preliminary Traffic Control Plan	0	1	4	7	10	13	
L6.	Substantial Completion Requirements	0	1	4	6	9	11	
							CATEGORY L TOTAL	
Section III Maximum Score = 341	**SECTION III TOTAL**							

Appendix 7. APRA Elements Sorted by Weight

Element ID	Element Name	Weight
C4	Determination of Utility Impacts	30
A3	Programming & Funding Data	30
C3	Survey of Existing Environmental Conditions	26
A2	Investment Studies & Alternatives Assessments	25
I1	Long-Lead Parcel & Utility Adjustment Identification	24
E3	Schematic Layouts	24
B1	Design Philosophy	23
A1	Need & Purpose Documentation	23
A5	Public Involvement	23
D5	Environmental Documentation	22
K2	Design & Construction Cost Estimates	21
A4	Key Team Member Coordination	21
K1	Right-of-Way & Utilities Cost Estimates	21
E1	Horizontal & Vertical Alignment	20
I4	Utility Agreement & Joint-Use Contracts	20
D9	Constraints Mapping	19
D10	Right-of-Way Site Issues	19
C2	Evaluation of Compliance Requirements	19
I3	Local Public Agencies Utilities Contracts & Agreements	19
B4	Future Expansion & Alteration Considerations	19
D3	Surveys & Planimetrics	18
D2	Hydrological Characteristics	18
E4	Cross-Sectional Elements	18
B2	Operating Philosophy	18

Element ID	Element Name	Weight
F2	Hydraulic Structures	18
G2	Constructability	18
D4	Permitting Requirements	17
E2	Control of Access	17
K3	Project Cost Control	17
D1	Geotechnical Characteristics	16
F1	Bridge Structure Elements	16
B3	Maintenance Philosophy	16
K4	Project Schedule Control	16
D8	Right-of-Way Mapping	16
L2	Interagency Coordination	15
C1	Functional Classification & Use	15
L3	Local Public Agency Contractual Agreements	15
D6	Property Descriptions	15
L1	Environmental Commitments & Mitigation	15
F3	Miscellaneous Design Elements	14
L4	Interagency Joint-Use Agreements	14
I8	Appraisal Requirements	14
I6	Design/Construction Plan & Approach	14
J2	Documentation/Deliverables	13
L5	Preliminary Traffic Control Plan	13
H3	Equipment Utility Requirements	13
K6	Safety Procedures	13
I5	Project Delivery Method & Contracting Strategies	13
D7	Ownership Determinations	13

Element ID	Element Name	Weight
I2	Long-Lead/Critical Equipment & Materials Identification	12
C5	Value Engineering	12
I9	Advance Acquisition Requirements	11
L6	Substantial Completion Requirements	11
G1	Provisional Maintenance Requirements	11
J1	CADD/Model Requirements	10
I7	Procurement Procedures & Plans	10
K5	Project Quality Assurance & Control	10
H1	Equipment List	9
H2	Equipment Location Drawings	8

Appendix 8. Select Test Meeting Documents

Example of APRA Test Meeting Agenda

MEETING DETAILS:

Date:	June 22, 2007
Time:	9:00AM – 11:30 AM
Location:	TxDOT Brownwood District Office 2495 Highway 183 North, Brownwood, Texas 76802
Re:	Advance Planning Risk Analysis

TOPICS OF DISCUSSION:

VI. Introduction & Demonstration of the APRA *(9:00 – 9:30 am)*

VII. Testing the APRA on projects *(9:30 – 11:30 am)*

Example of APRA Test Questionnaire for Completed Projects

0-5478 TxDOT Research Project

ADVANCE PLANNING RISK ANALYSIS (APRA) FOR TRANSPORTATION PROJECTS

APRA VALIDATION QUESTIONAIRE FOR <u>COMPLETED</u> PROJECTS

Center for Transportation Research
The University of Texas at Austin

How to Complete this Questionnaire

1. Read the Introduction, Potential Use and Benefits of the APRA, and Research Methodology sections in the two following pages
2. Select a completed project for the purpose of testing the APRA; the preferred characteristics of the project include:
    - Completed within the last 3 years
    - Had a budget of $5 million or more
    - Used Traditional (Design-Bid-Build) project delivery method
    - Be one of the project types listed in question c, section "2.1. General Information"
3. Fill in the background and project information in Sections 1 and 2[3]
4. Form a team to assess the project using the APRA; the team should:
    - Have 2—5 people who were involved in the project
    - Include (but not be limited to) people from design, planning & programming, ROW & Utilities, and environmental.
5. Together with CTR researchers, assess the APRA element by element using the detailed instructions in Section 3.
6. Together with CTR researchers, provide feedback by filling in Section 4.

[3] This step can be done during step 5 if that is more convenient.

ADVANCE PLANNING RISK ANALYSIS (APRA) FOR TRANSPORTATION PROJECTS

Introduction

Research in the building and industrial construction sectors has proven that the more effort put in the early phase of planning, the more the chance of project success. These sectors have tools, such as Project Definition Rating Index, that can help project team identify and manage critical risk elements in an effective manner. Given the different nature of building and industrial projects versus transportation projects, these tools cannot be successfully used in transportation. A similar tool for transportation projects, if developed, would give the similar benefits as the tools in building and industrial construction do.

TxDOT Research Project 0-5478 team is developing the Advance Planning Risk Analysis as a best practices tool for improving the effectiveness of the project development process on transportation projects. The APRA is envisioned to help the project development team to improve the process through structured yet flexible risk management, which consists of identifying, analyzing, and controlling risk issues. Fifty-nine risk issues have been identified by the research project team. These issues were grouped into 12 categories, which are further grouped into 3 sections. Upon completion, the tool can be used to rate a project and yield a score and generate a list of issues to be addressed. The score and the list can be used to evaluate riskiness of the project and its chance for success and identify the areas that the project team needs to address.

Potential Use and Benefits of the APRA

The APRA is expected to help improve the effectiveness of the project development process of the transportation process and maximize the chance of project success. The APRA can be used as:

- A checklist of critical risk elements of concern for project team;
- A means to monitor progress at various stages during the project development process;
- A communication and alignment tool among major project stakeholders such as owner, designer, and contractor;
- A means for reconciling differences among project team members;
- A list of standardized terminology for the project development process;
- A standard for managing project risks in early planning phase of transportation projects;
- A training tool for organizations and individuals;

- A benchmarking tool for evaluating projects within an organization against the performance of projects in the past to help with predicting project success probability.

Research Methodology

The final draft of the APRA has been developed and is currently being validated through testing on real transportation projects. Major steps of the methodology are:

- **Identification and categorization:** the first step of this research project was to identify and categorize the critical risk elements in the early planning phase of transportation projects. Current literature on related topics was reviewed and experienced professionals from TxDOT districts and divisions were interviewed to help identify and categorize the critical elements.
- **Weighting:** the elements were then evaluated with respect to their relative importance to the project with the input from 51 TxDOT professionals participated in 6 workshops throughout Texas.
- **Practical tool development:** the weighted elements constitute the main part of the APRA tool. In order for the users to use it efficiently, an electronic version of the tool is being developed. Feedback from the testing in the next step will be used to finalize this version of the tool.
- **Validation:** the next step is to test the tool on real projects to observe the use of the tool in practice and draw conclusions on the usefulness of the tool. The survey using questionnaire is the essence of this testing process. The survey documents include this introduction to the APRA and its development, a questionnaire to be filled out by the participants (yellow), and the "APRA Elements Descriptions" document. When participating in this survey by filling out the attached questionnaire, you are contributing significantly to the successful development of the APRA tool. This is the current step of the research project.
- **Validation data analysis:** after collecting the test data, analysis will be performed to draw conclusions on the use and usefulness of the tool.
- **Finalizing research products:** the final step in this research project is to finalize the research products, including the electronic version of the tool, research report, and user guide.

1. Background Information

Date:

Point of Contact:

a. Name:
b. Title:
c. Address:
d. Tel. No.: Fax. No.:
e. E-mail:

2. Project Information

General Information

a. Project Name:
b. Location of the Project:
c. What type is this project?

[ ] Convert Non-Freeway to Freeway	[ ] Interchange (New or Reconstruct)
[ ] Widen Freeway	[ ] Bridge Widening or Rehabilitation
[ ] Widen Non-Freeway	[ ] Bridge Replacement
[ ] New Location Freeway	[ ] Upgrade to Standards - Freeway
[ ] New Location Non-Freeway	[ ] Upgrade to Standards - Non-Freeway

d. Project size and general descriptions (*i.e., 5 miles expansion*):

e. Please describe any unique characteristic of this project (*e.g., significant geometric complexity, significant environmental impact*):

f. How many ROW parcels were acquired for the project?

g. How many utility adjustments were completed for the project?

Schedule Information

a. Please provide the following **schedule** information:

Item	Planned at Start of *PS&E Development* *(Design Conference)* (mm/dd/yy)	Actual (mm/dd/yy)
Right of Way Release Date		
Design Conference Date		
Letting Date		
End Date of Construction		

b. Please list significant causes of schedule changes and their corresponding time extensions/reductions that you know of and indicate whether they were an extension (Ext.) or reduction (Red.). (*Write on the back of this sheet if you need more room.*)

Delay	Months	Ext.	Red.
....	....	[ ]	[ ]
....	....	[ ]	[ ]
....	....	[ ]	[ ]
....	....	[ ]	[ ]

Please give any additional comments regarding any causes or effects of schedule changes?

Cost Information

a. Please provide the following **cost** information:

Item	Estimated Cost at Start of *PS&E Development* *(Design Conference)*	Actual Cost
PS&E		
ROW		
Utilities		
Construction		

Change Information

a. What was the total number of change orders issued (including during both PS&E development and construction)?

b. What was the total dollar amount of all change orders: $

Please give any comments on significant changes and what/how they affect the project's objectives (*e.g., time, cost*)

Owner Satisfaction

a. Based on the original plan/intent of the project set prior to the beginning of PS&E development, rate how the constructed project matches the original plan/intent: (*circle only one*)

1	2	3	4	5	6	7	8	9	10
Very Different									Perfectly Matches

Please give a brief explanation of your choice:

b. Reflecting on the overall project, rate how successful you feel the project has been: (*circle only one*)

1	2	3	4	5	6	7	8	9	10
Very Unsuccessful									Very Successful

Please give any additional comments regarding owner satisfaction:

3. Project Rating Information

Please complete the Project Rating Information form in the next few pages. Instructions for completing this form are explained below.

INSTRUCTIONS FOR RATING A PROJECT

The Advance Planning Risk Analysis (APRA) is intended to evaluate the level of scope definition of a project when PS&E (Plans, Specifications, and Estimates) development is about to begin. When evaluating a project, the team involved in the advance planning effort should consider the level of definition of each element in the APRA **at the time the project was ready to begin the development of PS&E**. For the purposes of this research, the project must have been substantially **completed within the last 3 years** and had a budget of at least **$5 million**, ideally greater than $10 million. The project should have used traditional project delivery method (Design-Bid-Build) and been one of the 10 types listed in question c, section "2.1. General Information".

The APRA consists of 3 sections, which are broken into 12 categories that contain 59 elements. Evaluation is performed for each individual element. Elements should be rated numerically from 0 to 5 based on its level of definition at the time when PS&E is about to begin. Think of this as a "zero defects" type of evaluation. Elements that were as well defined as possible should receive a perfect rating of "one". Elements that were completely undefined should receive a rating of "five". All other elements should receive a "two", "three", or "four" depending on their levels of definition. Those elements deemed not applicable for the project under consideration should receive a "zero". The ratings are defined as follows:

0 – Not Applicable:
The element is not part of the project requirements

1 – Complete Definition:
The element is well defined, no more work required before PS&E development

2 – Minor Deficiencies:
Some minor work needed for several items in the element before PS&E development

3 – Some Deficiencies:
Major work needed for some items or some work needed for most of the items in the element before PS&E development

4 – Major Deficiencies:
Major work needed for most of the items in the element before PS&E development

5 – Incomplete or Poor Definition:

The element is poorly defined, major work needed for (almost) all items in the element before PS&E development

Steps to rate an element:

1. Read its definition in the "APRA Elements Descriptions" document. Some elements have a list of items to be considered when evaluating their levels of definition. These lists may be used as checklists. Note, however, that some of these items may not be applicable for your project.
2. Refer to the "Project Rating Information" form and locate the element. Recall back to the **time of beginning of PS&E development** and determine how much about the element was known at that point in time.
3. Choose the appropriate (only one) definition level for the element (0, 1, 2, 3, 4, or 5) and check (√) the corresponding box. It should be reminded again that the time of determining the definition level is **at the beginning of PS&E development**.
4. Repeat the above steps for each of the 59 elements in the APRA. Be sure to rate each element.

Example of rating an APRA element:

Assuming you are about to rate element C3 (Survey of Existing Environmental Conditions) using the instructions above.

1. You read the element's descriptions provided in the "APRA Elements Descriptions" document and find that a number of surveys need to be done and a list of hazardous materials be identified, among others (Figure 1).
2. You **recall back to the time of beginning PS&E development** and find that surveys on natural resources and cultural resources had been done very well; hazardous materials on the site had also been identified. However, air quality and noise surveys had not been completed at that time. You feel that the element had *some deficiencies* that should have been addressed before starting PS&E development.
3. You choose definition level 3 for the element and check (√) the corresponding box (*some deficiencies*) in the "Project Rating Information" sheet of the questionnaire (Figure 2).
4. You then move to the next element, C4 (Determination of Utility Impacts), until all the elements have been rated.

C3. Survey of Existing Environmental Conditions

A preliminary survey consists of fieldwork and data acquisition from a variety of sources, including previous surveys, geographic information systems, and resource agency databases. Identifying problematic issues at an early stage in the project development process enables adequate time to address and mitigate these concerns Issues to consider include:

- ❑ Natural resource surveys:
  - ❑ Endangered species
  - ❑ Wetland status
  - ❑ Bodies of water
  - ❑ Existing and potential park system land
  - ❑ Permit needs
- ❑ Cultural resource surveys:
  - ❑ Historical preservation
  - ❑ Existence of cemeteries
  - ❑ Archaeological sites
- ❑ Air quality surveys:
  - ❑ Mobile source pollutants
  - ❑ Air quality analysis
  - ❑ Congestion mitigation-air quality
- ❑ Noise surveys:
  - ❑ Evaluation of need for abatement
- ❑ Hazardous materials:
  - ❑ Existing land use
  - ❑ Superfund and regulatory agency database review
  - ❑ Underground storage tanks
  - ❑ Site visits
  - ❑ Local inhabitant interviews
- ❑ Socioeconomic Impacts
- ❑ Other

Figure 1. Example of an Element's Description (Element C3)

SECTION I - BASIS OF PROJECT DECISION							
CATEGORY Element		**Definition Level**					
		0	**1**	**2**	**3**	**4**	**5**
C. PROJECT REQUIREMENTS							
	...						
C3.	Survey of Existing Environmental Conditions				√		
	...						

Figure 2. Example of Selecting an Element's Definition Level

PROJECT RATING INFORMATION

SECTION I - BASIS OF PROJECT DECISION						
	Definition Level					
CATEGORY Element	**0**	**1**	**2**	**3**	**4**	**5**
A. PROJECT STRATEGY						
A1. Need & Purpose Documentation						
A2. Investment Studies & Alternatives Assessments						
A3. Programming & Funding Data						
A4. Key Team Member Coordination						
A5. Public Involvement						
B. OWNER/OPERATOR PHILOSOPHIES						
B1. Design Philosophy						
B2. Operating Philosophy						
B3. Maintenance Philosophy						
B4. Future Expansion & Alteration Considerations						
C. PROJECT REQUIREMENTS						
C1. Functional Classification & Use						
C2. Evaluation of Compliance Requirements						
C3. Survey of Existing Environmental Conditions						
C4. Determination of Utility Impacts						
C5. Value Engineering						

Please check (√) only 1 box for each element. Please do not leave any elements blank

0 = Not Applicable **2 = Minor Deficiencies** **4 = Major Deficiencies**
1 = Complete Definition **3 = Some Deficiencies** **5 = Incomplete or Poor Definition**

SECTION II - BASIS OF DESIGN						
	Definition Level					
CATEGORY Element	**0**	**1**	**2**	**3**	**4**	**5**
D. SITE INFORMATION						
D1. Geotechnical Characteristics						
D2. Hydrological Characteristics						
D3. Surveys & Planimetrics						
D4. Permitting Requirements						
D5. Environmental Documentation						
D6. Property Descriptions						
D7. Ownership Determinations						
D8. Right-of-Way Mapping						
D9. Constraints Mapping						
D10. Right-of-Way Site Issues						
E. LOCATION & GEOMETRY						
E1. Horizontal & Vertical Alignment						
E2. Control of Access						
E3. Schematic Layouts						
E4. Cross-Sectional Elements						
F. STRUCTURES						
F1. Bridge Structure Elements						
F2. Hydraulic Structures						
F3. Miscellaneous Design Elements						
G. DESIGN PARAMETERS						
G1. Provisional Maintenance Requirements						
G2. Constructability						
H. INSTALLED EQUIPMENT						
H1. Equipment List						
H2. Equipment Location Drawings						
H3. Equipment Utility Requirements						

Please check (√) only 1 box for each element. Please do not leave any elements blank

0 = Not Applicable **2 = Minor Deficiencies** **4 = Major Deficiencies**
1 = Complete Definition **3 = Some Deficiencies** **5 = Incomplete or Poor Definition**

SECTION III - EXECUTION APPROACH						
CATEGORY Element	Definition Level					
	0	1	2	3	4	5
I. ACQUISITION STRATEGY						
I1. Long-Lead Parcel & Utility Adjustment Identification						
I2. Long-Lead/Critical Equipment & Materials Identification						
I3. Local Public Agencies Utilities Contracts & Agreements						
I4. Utility Agreement & Joint-Use Contracts						
I5. Project Delivery Method & Contracting Strategies						
I6. Design/Construction Plan & Approach						
I7. Procurement Procedures & Plans						
I8. Appraisal Requirements						
I9. Advance Acquisition Requirements						
J. DELIVERABLES						
J1. CADD/Model Requirements						
J2. Documentation/Deliverables						
K. PROJECT CONTROL						
K1. Right-of-Way & Utilities Cost Estimates						
K2. Design & Construction Cost Estimates						
K3. Project Cost Control						
K4. Project Schedule Control						
K5. Project Quality Assurance & Control						
K6. Safety Procedures						
L. PROJECT EXECUTION PLAN						
L1. Environmental Commitments & Mitigation						
L2. Interagency Coordination						
L3. Local Public Agency Contractual Agreements						
L4. Interagency Joint-Use Agreements						
L5. Preliminary Traffic Control Plan						
L6. Substantial Completion Requirements						

Please check (√) only 1 box for each element. Please do not leave any elements blank

0 = Not Applicable **2 = Minor Deficiencies** **4 = Major Deficiencies**
1 = Complete Definition **3 = Some Deficiencies** **5 = Incomplete or Poor Definition**

4. Follow-up Information

a. How long did it take you (or your team) to fill out the forms? Please specify in total work-hours (*e.g., a team of 3 working for 4 hours equals 12 total work-hours*).

Background and Project Information (parts 1 & 2): .... total work-hours
Project Rating Information (part 3): .... total work-hours

b. Please write down names of all experts participated in filling out this questionnaire:

Thank you very much for your participation in this survey!

Please email a scanned copy of this form to Dr. Carlos Caldas (caldas@mail.utexas.edu) or mail it to:

Dr. Carlos H. Caldas
University of Texas at Austin
Dept. of Civil, Arch. & Environmental Engineering
1 University Station C1752
Austin, TX 78712-0273

Example of APRA Test Questionnaire for Ongoing Projects

0-5478 TxDOT Research Project

ADVANCE PLANNING RISK ANALYSIS (APRA) FOR TRANSPORTATION PROJECTS

APRA VALIDATION QUESTIONAIRE FOR ON-GOING PROJECTS

Center for Transportation Research
The University of Texas at Austin

How to Complete this Questionnaire

7. Read the Introduction, Potential Use and Benefits of the APRA, and Research Methodology sections in the two following pages

8. Select an on-going project for the purpose of testing the APRA; the preferred characteristics of the project include:
   - Currently be prior to the beginning of PS&E development
   - Have an estimated budget of $5 million or more
   - Use Traditional (Design-Bid-Build) project delivery method
   - Be one of the project types listed in question c, section "2.1. General Information"

9. Fill in the background and project information in Sections 1 and 2[4]

10. Form a team to assess the project using the APRA; the team should:
    - Have 2—5 people who were involved in the project
    - Include (but not be limited to) people from design, planning & programming, ROW & Utilities, and environmental.

11. Together with CTR researchers, assess the APRA element by element using the detailed instructions in Section 3.

12. Provide feedback by filling in Section 4.

[4] This step can be done during step 5 if that is more convenient.

ADVANCE PLANNING RISK ANALYSIS (APRA) FOR TRANSPORTATION PROJECTS

Introduction

Research in the building and industrial construction sectors has proven that the more effort put in the early phase of planning, the more the chance of project success. These sectors have tools, such as Project Definition Rating Index, that can help project team identify and manage critical risk elements in an effective manner. Given the different nature of building and industrial projects versus transportation projects, these tools cannot be successfully used in transportation. A similar tool for transportation projects, if developed, would give the similar benefits as the tools in building and industrial construction do.

TxDOT Research Project 0-5478 team is developing the Advance Planning Risk Analysis as a best practices tool for improving the effectiveness of the project development process on transportation projects. The APRA is envisioned to help the project development team to improve the process through structured yet flexible risk management, which consists of identifying, analyzing, and controlling risk issues. Fifty-nine risk issues have been identified by the research project team. These issues were grouped into 12 categories, which are further grouped into 3 sections. Upon completion, the tool can be used to rate a project and yield a score and generate a list of issues to be addressed. The score and the list can be used to evaluate riskiness of the project and its chance for success and identify the areas that the project team needs to address.

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The APRA is expected to help improve the effectiveness of the project development process of the transportation process and maximize the chance of project success. The APRA can be used as:

- A checklist of critical risk elements of concern for project team;
- A means to monitor progress at various stages during the project development process;
- A communication and alignment tool among major project stakeholders such as owner, designer, and contractor;
- A means for reconciling differences among project team members;
- A list of standardized terminology for the project development process;
- A standard for managing project risks in early planning phase of transportation projects;

- A training tool for organizations and individuals;
- A benchmarking tool for evaluating projects within an organization against the performance of projects in the past to help with predicting project success probability.

Research Methodology

The final draft of the APRA has been developed and is currently being validated through testing on real transportation projects. Major steps of the methodology are:

- **Identification and categorization:** the first step of this research project was to identify and categorize the critical risk elements in the early planning phase of transportation projects. Current literature on related topics was reviewed and experienced professionals from TxDOT districts and divisions were interviewed to help identify and categorize the critical elements.
- **Weighting:** the elements were then evaluated with respect to their relative importance to the project with the input from 51 TxDOT professionals participated in 6 workshops throughout Texas.
- **Practical tool development:** the weighted elements constitute the main part of the APRA tool. In order for the users to use it efficiently, an electronic version of the tool is being developed. Feedback from the testing in the next step will be used to finalize this version of the tool.
- **Validation:** the next step is to test the tool on real projects to observe the use of the tool in practice and draw conclusions on the usefulness of the tool. The survey using questionnaire is the essence of this testing process. The survey documents include this introduction to the APRA and its development, a questionnaire to be filled out by the participants (yellow), and the "APRA Elements Descriptions" document. When participating in this survey by filling out the attached questionnaire, you are contributing significantly to the successful development of the APRA tool. This is the current step of the research project.
- **Validation data analysis:** after collecting the test data, analysis will be performed to draw conclusions on the use and usefulness of the tool.
- **Finalizing research products:** the final step in this research project is to finalize the research products, including the electronic version of the tool, research report, and user guide.

1. Background Information

Date:

Point of Contact:

1. Name:
2. Title:
3. Address:
4. Tel. No.: Fax. No.:
5. E-mail:

2. Project Information

General Information

a. Project Name:
b. Location of the Project:
c. What type is this project?

[ ] Convert Non-Freeway to Freeway	[ ] Interchange (New or Reconstruct)
[ ] Widen Freeway	[ ] Bridge Widening or Rehabilitation
[ ] Widen Non-Freeway	[ ] Bridge Replacement
[ ] New Location Freeway	[ ] Upgrade to Standards - Freeway
[ ] New Location Non-Freeway	[ ] Upgrade to Standards - Non-Freeway

d. Project size and general descriptions (*i.e., 5 miles expansion*):

e. Please describe any unique thing about this project (*e.g., significant geometric complexity, significant environmental impact*):

f. How many ROW parcels are planned for acquisition for the project?

g. How many utility adjustments are planned for the project? (*if known*)

h. Where is the project at in the following project development sub-processes? (*Project Development Process Chart can be referred to for terminology*)

For example:

Planning & Programming: *completed*

Preliminary Design: *completed "Geometric Schematic Approval"*

Environmental: *completed "Public Hearing"*

ROW & Utilities: *50% "ROW Map and Property Descriptions"*

PS&E Development: *not yet started*

Planning & Programming:

Preliminary Design:

Environmental:

ROW & Utilities:

PS&E Development:

Schedule Information

Please provide the following **schedule** information:

Item	Planned at time of *Evaluation* (mm/dd/yy)
Right of Way Release Date	
Design Conference Date	
Letting Date	
End Date of Construction	

Cost Information

Please provide the following **cost** information:

Item	Estimated Cost at time of *Evaluation*
PS&E	
ROW	
Utilities	
Construction	

3. Project Rating Information

Please, **as a team**, complete the Project Rating Information form in the next few pages. Instructions for completing this form are explained below.

INSTRUCTIONS FOR RATING A PROJECT

The Advance Planning Risk Analysis (APRA) is intended to help project team with evaluating the level of scope definition of a project during the project development (advance planning) phase. When evaluating a project, the team involved in the advance planning effort should consider the level of definition of each element in the APRA **at the time of the evaluation**. Ideally, the team for this evaluation should include (but not be limited to) people from design, planning, ROW & Utilities, and environmental. For the purposes of this research, the project must be **prior to the beginning of PS&E development** and have a budget of at least $5 million, ideally greater than $10 million. The project should be using traditional project delivery method (Design-Bid-Build) and one of the 10 types listed in question c, section "2.1. General Information".

The APRA consists of 3 sections, which are broken into 12 categories that contain 59 elements. Evaluation is performed for each individual element. Elements should be rated numerically from 0 to 5 based on its level of definition at the time of the evaluation. Think of this as a "zero defects" type of evaluation. Elements that were as well defined as possible should receive a perfect rating of "one". Elements that were completely undefined should receive a rating of "five". All other elements should receive a "two", "three", or "four" depending on their levels of definition. Those elements deemed not applicable for the project under consideration should receive a "zero". The ratings are defined as follows:

0 – Not Applicable:
The element is not part of the project requirements PS&E development

1 – Complete Definition:
The element is well defined, no more work required PS&E development

2 – Minor Deficiencies:
Some minor work needed for several items in the element PS&E development

3 – Some Deficiencies:
Major work needed for some items or some work needed for most of the items in the element PS&E development

4 – Major Deficiencies:
Major work needed for most of the items in the element PS&E development

5 – Incomplete or Poor Definition:
The element is poorly defined, major work needed for (almost) all items in the element PS&E development

Steps to rate an element:

5. Read its definition in the "APRA Elements Descriptions" document. Some elements have a list of items to be considered when evaluating their levels of definition. These lists may be used as checklists. Note, however, that some of these items may not be applicable for your project.
6. Refer to the "Project Rating Information" form and locate the element. As a team, please choose only one definition level (0, 1, 2, 3, 4, or 5) for that element based on your perception of how well it is defined at **this** time of evaluation.
7. With the team's consensus, choose the appropriate definition level for the element and check (√) the corresponding box.
8. Repeat the above steps for each of the 59 elements in the APRA. Be sure to rate each element.

Example of rating an APRA element:

Assuming you are about to rate element C3 (Survey of Existing Environmental Conditions) using the instructions above.

5. You read the element's descriptions provided in the "APRA Elements Descriptions" document and find that a number of surveys need to be done and a list of hazardous materials be identified, among others (Figure 1).
6. You, as a team, find that surveys on natural resources and cultural resources have been done very well; hazardous materials on the site have also been identified. However, air quality and noise surveys have not been completed at this time. You feel that the element has *some deficiencies* that should be addressed before starting PS&E development.
7. You, with the team's consensus, choose definition level 3 for the element and check (√) the corresponding box (*some deficiencies*) in the "Project Rating Information" sheet of the questionnaire (Figure 2).
8. You then move to the next element, C4 (Determination of Utility Impacts), until all the elements have been rated.

C3. Survey of Existing Environmental Conditions

A preliminary survey consists of fieldwork and data acquisition from a variety of sources, including previous surveys, geographic information systems, and resource agency databases. Identifying problematic issues at an early stage in the project development process enables adequate time to address and mitigate these concerns Issues to consider include:

- ❑ Natural resource surveys:
  - ❑ Endangered species
  - ❑ Wetland status
  - ❑ Bodies of water
  - ❑ Existing and potential park system land
  - ❑ Permit needs
- ❑ Cultural resource surveys:
  - ❑ Historical preservation
  - ❑ Existence of cemeteries
  - ❑ Archaeological sites
- ❑ Air quality surveys:
  - ❑ Mobile source pollutants
  - ❑ Air quality analysis
  - ❑ Congestion mitigation-air quality
- ❑ Noise surveys:
  - ❑ Evaluation of need for abatement
- ❑ Hazardous materials:
  - ❑ Existing land use
  - ❑ Superfund and regulatory agency database review
  - ❑ Underground storage tanks
  - ❑ Site visits
  - ❑ Local inhabitant interviews
- ❑ Socioeconomic Impacts
- ❑ Other

Figure 1. Example of an Element's Description (Element C3)

SECTION I - BASIS OF PROJECT DECISION							
CATEGORY Element		**Definition Level**					
		0	**1**	**2**	**3**	**4**	**5**
C. PROJECT REQUIREMENTS							
	...						
C3.	Survey of Existing Environmental Conditions				√		
	...						

Figure 2. Example of Selecting an Element's Definition Level

SECTION I - BASIS OF PROJECT DECISION						
CATEGORY Element	**Definition Level**					
	0	**1**	**2**	**3**	**4**	**5**
A. PROJECT STRATEGY						
A1. Need & Purpose Documentation						
A2. Investment Studies & Alternatives Assessments						
A3. Programming & Funding Data						
A4. Key Team Member Coordination						
A5. Public Involvement						
B. OWNER/OPERATOR PHILOSOPHIES						
B1. Design Philosophy						
B2. Operating Philosophy						
B3. Maintenance Philosophy						
B4. Future Expansion & Alteration Considerations						
C. PROJECT REQUIREMENTS						
C1. Functional Classification & Use						
C2. Evaluation of Compliance Requirements						
C3. Survey of Existing Environmental Conditions						
C4. Determination of Utility Impacts						
C5. Value Engineering						

Please check (√) only 1 box for each element. Please do not leave any elements blank

0 = Not Applicable **2 = Minor Deficiencies** **4 = Major Deficiencies**
1 = Complete Definition **3 = Some Deficiencies** **5 = Incomplete or Poor Definition**

PROJECT RATING INFORMATION

SECTION II - BASIS OF DESIGN						
	Definition Level					
CATEGORY Element	**0**	**1**	**2**	**3**	**4**	**5**
D. SITE INFORMATION						
D1. Geotechnical Characteristics						
D2. Hydrological Characteristics						
D3. Surveys & Planimetrics						
D4. Permitting Requirements						
D5. Environmental Documentation						
D6. Property Descriptions						
D7. Ownership Determinations						
D8. Right-of-Way Mapping						
D9. Constraints Mapping						
D10. Right-of-Way Site Issues						
E. LOCATION & GEOMETRY						
E1. Horizontal & Vertical Alignment						
E2. Control of Access						
E3. Schematic Layouts						
E4. Cross-Sectional Elements						
F. STRUCTURES						
F1. Bridge Structure Elements						
F2. Hydraulic Structures						
F3. Miscellaneous Design Elements						
G. DESIGN PARAMETERS						
G1. Provisional Maintenance Requirements						
G2. Constructability						
H. INSTALLED EQUIPMENT						
H1. Equipment List						
H2. Equipment Location Drawings						
H3. Equipment Utility Requirements						

Please check (√) only 1 box for each element. Please do not leave any elements blank

0 = Not Applicable **2 = Minor Deficiencies** **4 = Major Deficiencies**
1 = Complete Definition **3 = Some Deficiencies** **5 = Incomplete or Poor Definition**

SECTION III - EXECUTION APPROACH						
	Definition Level					
CATEGORY Element	**0**	**1**	**2**	**3**	**4**	**5**
I. ACQUISITION STRATEGY						
I1. Long-Lead Parcel & Utility Adjustment Identification						
I2. Long-Lead/Critical Equipment & Materials Identification						
I3. Local Public Agencies Utilities Contracts & Agreements						
I4. Utility Agreement & Joint-Use Contracts						
I5. Project Delivery Method & Contracting Strategies						
I6. Design/Construction Plan & Approach						
I7. Procurement Procedures & Plans						
I8. Appraisal Requirements						
I9. Advance Acquisition Requirements						
J. DELIVERABLES						
J1. CADD/Model Requirements						
J2. Documentation/Deliverables						
K. PROJECT CONTROL						
K1. Right-of-Way & Utilities Cost Estimates						
K2. Design & Construction Cost Estimates						
K3. Project Cost Control						
K4. Project Schedule Control						
K5. Project Quality Assurance & Control						
K6. Safety Procedures						
L. PROJECT EXECUTION PLAN						
L1. Environmental Commitments & Mitigation						
L2. Interagency Coordination						
L3. Local Public Agency Contractual Agreements						
L4. Interagency Joint-Use Agreements						
L5. Preliminary Traffic Control Plan						
L6. Substantial Completion Requirements						

Please check (√) only 1 box for each element. Please do not leave any elements blank

0 = Not Applicable **2 = Minor Deficiencies** **4 = Major Deficiencies**
1 = Complete Definition **3 = Some Deficiencies** **5 = Incomplete or Poor Definition**

PROJECT RATING INFORMATION

4. Follow-up Information

a. How long did it take you (or your team) to fill out the forms? Please specify in total work-hours (*e.g., a team of 3 working for 4 hours equals 12 total work-hours*).

Background and Project Information (parts 1 & 2): .... total work-hours
Project Rating Information (part 3): .... total work-hours

b. Please write down names of all experts participated in filling out this questionnaire:

Thank you very much for your participation in this survey!

Please email a scanned copy of this form to Dr. Carlos Caldas (caldas@mail.utexas.edu) or mail it to:

Dr. Carlos H. Caldas
University of Texas at Austin
Dept. of Civil, Arch. & Environmental Engineering
1 University Station C1752
Austin, TX 78712-0273

Post-Test Questionnaire

0-5478 TxDOT Research Project

ADVANCE PLANNING RISK ANALYSIS (APRA) FOR TRANSPORTATION PROJECTS

APRA ASSESSMENT QUESTIONNAIRE

Name:

Email: Phone:

1. The APRA method helps identify critical risk elements that need to be managed during the project development process.

1 2 3 4 5 6 7
Strongly Disagree Neutral Strongly Agree

2. The APRA method helps improve the advance planning process.

1 2 3 4 5 6 7
Strongly Disagree Neutral Strongly Agree

3. Please give a brief explanation of your choices above and any comments you have regarding the APRA method and its use

Thank you very much for your participation in this questionnaire!

Appendix 9. Summary of Issues from Tested Projects

PROJECT 2

- A realignment was needed due to inadequate consideration of relocation requirements of an oil well in the proposed Right-of-Way.
- There was a significant delay in the final acquisition of R/W by Ector County; it is believed to cause a delay of about 72 months.
- There were special provisions for R/W and utilities.
- There was a supplemental work order for the Engineering Consultant to correct the DTM (digital terrain model) from aerial photos. This work costed $32,000.
- There was no value engineering conducted.
- Geotechnical characteristics were poorly investigated.
- Cost estimates for design and construction were not well communicated to all parties.

PROJECT 3

- There was a considerable scope change, which caused changes in the R/W mapping.
- No public meeting was conducted. This was believed to be one of the reasons for delays in letting and R/W release.
- Utility impact was not verified until construction, when SUE was performed.
- There was poor definition/understanding of the properties and their owners.
- There were significant changes in the R/W maps.
- Condemnation took exceptionally longer than negotiation in acquiring the R/W: according to one expert, “condemnation kills the project.”
- There were a lot of issues related to Title curative, an issue second in seriousness only to condemnation.
- There was a significant delay in assigning appraisers to do appraisals.

PROJECT 4

- There were confusing unit systems: metric and imperial systems were used for R/W but only metric for construction.
- The project was the biggest one in Texas highway history up to 1998 with an extremely large number of parcels and displacements: 876.
- The traffic control plan was very complex, but none existed until PS&E.
- There was intensive involvement from many agencies.
- There were drainage issues.
- There were many environmental issues: for example, during construction a gas line was drilled into (while drilling a bridge column) which led to the need to evacuate a one square mile area; fortunately there was no ignition and no fatalities.
- The detour plan was outlined very late, after construction started.
- During design, there was poor involvement of construction: constructability was not addressed proactively.
- The utility agreement and joint-use contract needed to change.
- The combination of construction and R/W budgets made it tough to allocate money for R/W and construction specifically; in the past, R/W costs were satisfied from state money on a first-come, first-served basis.
- The budget, especially for R/W, was uncertain.
- Value engineering was not performed.

PROJECT 5

- Environmental approval was being sought late in the project, in parallel with the PS&E.
- Utilities were identified, but how and where they might affect the R/W acquisition and construction processes were not known.

- There was a big change in horizontal and vertical alignments, which caused changes in both design and R/W acquisition.
- There were drainage issues, specifically, there were changes in hydraulic structures due to poorly defined hydrological characteristics.
- There was a change from a flex base to an asphalt concrete base, hence a change in design.
- A need for an extra temporary access along the road arose, so there was a change in design, planning, and traffic control plan
- Many TxDOT professionals believe that TxDOT should not or does not have to deal with "contractor's stuff" such as procurement procedures and plans (element I.7.)

PROJECT 7

- Value engineering is done late in the design phase: for formality purposes only, making it ineffective.
- There was poor communication among disciplines.
- The first time ROWAPS (R/W Acquisition Professional Service) contract was used and was believed to delay the process by 4-6 months due to a steep learning curve in work coordination.
- There was not an assigned coordinator for R/W and utility.
- The project was shelved for a while due to some reason from the state.
- There was a change in drainage structures: a sign of poor or less-than-completely-informed design.
- There was a utility compaction failure.
- Illumination was added as a change.
- There was a change of hot mix type.
- The traffic control plan was poorly laid out.

PROJECT 8

- There were poorly understood geotechnical and hydrological characteristics during design that caused a lot of design changes later.
- The design changes to add a gutter instead of a ditch section caused a delay of 15 months.
- There were design changes for a canal crossing (conveyance of a water-irrigation canal across the road).
- There was a need to relocate a longitudinal irrigation canal.
- There was a need to remove asbestos lines.
- There was a change order for special handling of an asbestos pipe.
- There was a change in the purpose of the project (safety was added as an objective).
- There were significant changes in R/W requirements which caused changes in the R/W map.
- Shoulders were later added to the scope of the project.
- Underground tanks were found later during construction.
- No value engineering was performed.
- R/W cost was estimated but almost no double-checking: the result is a relatively poor estimate.
- No early traffic control plan existed.

PROJECT 10 (Ongoing Project)

- There was a poor level of involvement of the public and business owners at the beginning of the project; it was later improved.
- Funding from federal and state sources was not secured for changes: this posed risk should there be a need for a change in scope.
- There were some changes in access control as many properties were not taken into adequate consideration during preliminary design.
- Traffic control was poorly planned.

- Hazardous materials and underground tanks were not investigated, but the project team needed to wait until construction to see what issues might arise.
- The utility impact was not adequately determined, running the risk of hitting underground utilities in construction.
- One major property changed ownership in the middle of negotiation; therefore, R/W acquisition had to start over again.
- Constructability was not examined yet.

Appendix 10. Instructions for Facilitating an Assessment Meeting Using the APRA

From observation, an external facilitator (a person who is not directly involved with the project), has proven to be an essential ingredient in ensuring that the APRA assessment session is effective. The facilitator can be a person from internal to the organization, or an outside consultant, be he/she should be experienced in advance planning of the type of project under consideration and also should have excellent facilitation skills. The following issues should be addressed by the facilitator for to prepare for and conduct the APRA assessment.

Pre-meeting Activities

The facilitator should establish a meeting with the Project Manager/Engineer to receive a briefing on the nature and purpose of the project to be evaluated. The objective of this meeting is to learn enough about the project to ask intelligent/probing questions of the project team members while conducting the session. Many times, the "open ended" discussions concerning key elements provides the most value when conducting an APRA assessment. Therefore, it is the responsibility of the facilitator to ask the types of questions that will result in an open discussion. Gaining some insight prior to the assessment helps in this regard.

This meeting also serves as a good time to preview the APRA elements to see if some of them do not apply to the project at hand. This is especially true for small and renovation projects. In some cases, it is obvious that some of the elements do not apply and these can be removed in advance to save the team time in the assessment.

The facilitator should inform the Project Manager that this is her/his opportunity to listen to the team members to see how well they understand the scope of work. The project manager should work with the facilitator to probe the project team to ensure clear two-way understanding of scope requirements and expectations. If the project manager dominates the discussion, and subsequent scoring, the rest of the design team will quickly "clam up" and fall in line. This will result in an APRA assessment that reflects the understanding of the project manager, not the team members.

The facilitator should remind the project manager that the APRA assessment session is an opportunity to team build and align the team members on the critical requirements for the project. Experience has shown that serving food (perhaps lunch or breakfast) can help to increase participation as well as interaction between team members.

The facilitator and project manager should discuss the key stakeholders who should attend the session. Ensure that all key stakeholders are in attendance. Reducing the number of attendees will make the session go more efficiently, but this may compromise the true value of the APRA assessment. Work with the project manager to send out meeting notices in time for the major stakeholders to be able to attend.

Logistics

The facilitator should ensure that the facilities are large enough to accommodate the key project stakeholders in comfort. One method of assessment is to utilize a computer projector to keep score as assessment progresses. Therefore, a room with a screen, computer, and projector is a plus. The APRA can be conducted manually as well. When conducting manually, each participant will require a copy of the score sheet and Element Definitions so they can follow along.

An assessment session takes approximately 2 to 4 hours per project. An inexperienced team, or a very complex project, may well take the full four hours. As teams within an organization get accustomed to the APRA sessions, the time will drop to around two hours. However, it is the discussion occurring during the assessment session that is perhaps its most important benefit. Do not allow an artificial time limit to restrain the open communications between team members.

The session can be conducted over an extended lunch period. In this situation, it is best to start with a short lunch period as an ice breaker, then conduct the session. The facilitator should ensure that the room is set up in advance.

- Make sure the computer, projector, and programs are functioning.
- Set up the notes and Action Items pages
- Make sure all participants have the proper handouts
- When using the automated APRA Scoring Program, make sure the operator is skilled. Lack of computer skills and preparation can lead to ineffectiveness.
- Ensure the programs are loaded and working prior to the session.
- Identify a scribe to capture actions on a flip chart as the session progresses.

Participants

Suggested attendees of the assessment session may include:

- District engineer
- Transportation planning and development director
- District design engineer
- Area engineer

- Construction engineer
- Maintenance engineer
- Environmental coordinator
- Traffic engineer
- Right-of-way administrator
- Utility coordinator
- Contractors if possible.

It is important that all assessment session participants come prepared to actively engage in the assessment. Typically this can be facilitated by sending the APRA assessment sheets and element descriptions out ahead of time with a pre-reading assignment. Expectations of participants include:

- All should be prepared to discuss their understanding and concerns of the elements that apply to them.
- Design/engineering should be prepared to explain what they are doing in regards to each APRA element.
- The district engineer should voice expectations/requirements, and question the design team to ensure understanding.
- Roles and responsibilities during the assessment session should include:
- The project manager should assist the facilitator to probe the team members for answers and insight.
- The facilitator will ensure that everyone has an opportunity to voice their opinions and concerns.

Conducting the Session

- Facilitator should provide the team members with a short overview of the APRA.
- The facilitator or project manager should define the purpose of the assessment session.
- The project manager should give a quick update of the project and its status, including progress supporting the estimates and plans.

- The facilitator should explain the scoring mechanism (definition levels 0, 1, 2, 3, 4, and 5), and explain that the evaluation is not a democratic exercise; rather it is a consensus activity.
- The facilitator should explain that certain elements may apply more to certain team members or stakeholders. Make sure that these key stakeholders have the greatest say in deciding on level of definition.
- The facilitator should keep the session moving and not allowing the participants to “bog down.” Many times the participants want to “solve the problem” during the assessment session. Do not allow this to happen. Remember, the session is to perform a detailed assessment only, and actions can be performed later.
- The facilitator should always challenge assumptions and continue to ask the question, “is the material in writing?”

Assessment Session Objectives

1. Capture the degree of definition for each element.
2. Capture significant comments from open discussions.
3. Capture Action Items, assign responsibility and due dates (either at the end of the session, or shortly thereafter).
4. Ensure that the team understands the notes captured and agrees with the path forward.
5. Create alignment among the session attendees.

Roles and Responsibilities/Expectations

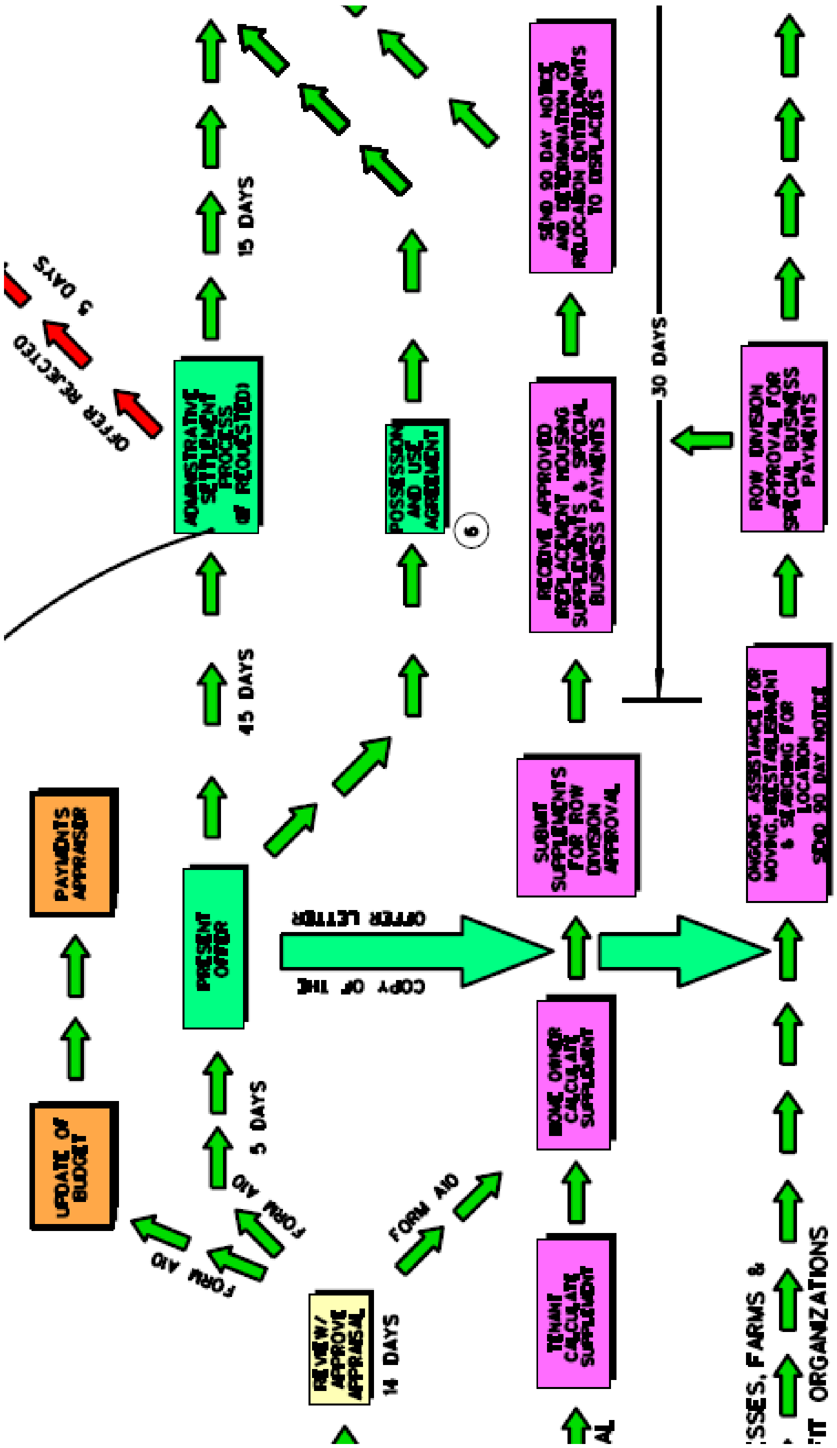
- Post session activities: The facilitator should ensure that the APRA notes, action items, and score card are published within 48 hours of the sessions. The ideal target is 24 hours.
- The facilitator should stay engaged with the team if possible to ensure that all Action Items are completed as required to support the scope definition process.
- The project manager should ensure that the actions are addressed.

Small Project Considerations

- Small or renovation projects may have several elements that do not apply.

- As previously mentioned, the facilitator and project manager can meet ahead of time to identify some of these elements.
- Assigning a zero to a significant number of APRA elements can greatly affect the score. It is best to use the normalized score in this case. In this case, less significant elements can have a more significant impact on the overall score. Be careful in interpretation of this score.

Appendix 11. Portion of the Right-of-Way Parcel Acquisition Flowchart



Appendix 12. Short Descriptions for Major Right-of-Way Acquisition Milestones

ID	Milestone	Description
1	Right-of-Way Release	Official start of the R/W acquisition process with a release from the ROW Division. ROW maps approved and the Agreement to Contribute Funds from the local agencies executed and monies received.
2	Title Commitment Received	Title commitment is received, for the first time, from the title company.
3	Appraisal Ordered	When an appraiser is assigned to do the appraisal of the parcel.
4	Approved by TxDOT	TxDOT completes its review and approves the appraisal for the first time.
5	Offer Presented to Owner	Offer is presented to the owner for the first time.
6	Admin Settlement Initiated (Date of Owner Request)	The land owner turns down the offer and requests an administrative settlement with a counter offer.
7	Offer Accepted by Owner (Conveyance Date)	Owner accepts and signs the Deed. The process proceeds to closing by the title company.
8	Possession and Use (Date Paid)	Partial payment is made. TxDOT has the right to use the property prior to completion of a full acquisition or eminent domain process.
9	TxDOT Approval of Final	If offer is rejected with no counter offer or if

ID	Milestone	Description
	Offer/Presented	the requested Administrative Settlement is not accepted, TxDOT prepares and approves Final Offer to the land owner.
10	Parcel Sent to Condemnation (E-49 to Division)	District's request to start the eminent domain process. Form E-49 is sent to the ROW Division.
11	Updated Appraisal Approved by TxDOT ROW Section	The updated appraisal, after the initiation of eminent domain process, is approved by the ROW division. ED still proceeds, but the negotiation process is reopened if a revised approved value of just compensation indicates an increase in value.
12	Minute Order Issued	Minute order is approved by the Transportation Commission for the eminent domain to proceed.
13	File Submitted to OAG	Eminent Domain package is submitted from the ROW Division to the office of the OAG for the preparation of the petition and other documents.
14	Law Suit (Petition) Filed	Once the Petition and additional documents are received from the OAG they are filed with court.
15	Date of Hearing	Date of hearing by the Special Commissioners.
16	Award Filed/Certified Copy Ordered	The judge signs the award.

ID	Milestone	Description
17	Date Objections Filed	Date that the owner or State files objections to the Commissioners Award.
18	Warrant Requested	Payment for the Commissioners Award is requested by TxDOT.
19	Judgment in Absence of Objections Filed	No objections filed and the JAO is filed with the court and County property records.
20	Date of Deposit into Registry of Court	The Award of Commissioners is deposited to the registry of the court. This is when the state has possession of the property.
21	Closing Date	Official closing for parcels acquired by negotiation.
22	30 Day Notice to Vacate Sent	Displacees receive the 30 day notice to vacate.
23	Actual Vacate Date	Displacees vacate the property.
24	Asbestos Testing Ordered	Any structures that have been acquired by the state are tested for the presence of asbestos. Any asbestos found is abated prior to the demolition of the structure.
25	Demolition Completed	The demolition of the improvements is complete.
26	Parcel Clear	Displacees are relocated and all improvements are removed. The parcel is ready for utility relocation/roadway construction to start.

Appendix 13. Actual, Estimated, and Residual Values of Total Duration for All Parcels

ID (Project-Parcel)	Actual Duration	Estimated Duration	Residual (Actual - Estimated)
2338W-1	224	192	32
2338W-2	245	192	53
2338W-4	330	192	138
2338W-5	225	192	33
2338W-6	267	192	75
2338W-7	254	192	62
2338W-8	586	414	172
2338W-9	224	192	32
2338W-10	225	192	33
2338W-11-A	350	192	158
2338W-11-B	350	192	158
2338W-12	245	192	53
2338W-18	224	192	32
2338W-19	225	192	33
2338W-20	238	192	46
2338W-21-A	881	867	14
2338W-28	667	783	-116
2338W-76-A	968	867	101
2338G-29	589	610	-21
2338G-30	712	762	-50
2338G-31	568	610	-42
2338G-32	543	610	-67
2338G-33-A	796	610	186
2338G-34	607	511	96
2338G-35	629	427	202
2338G-36	490	427	63

ID (Project-Parcel)	Actual Duration	Estimated Duration	Residual (Actual - Estimated)
2338G-37	312	427	-115
2338G-38	629	427	202
2338G-39	812	649	163
2338G-40	312	427	-115
2338G-41	602	649	-47
2338G-42	546	427	119
2338G-44	936	800	136
2338G-45	734	649	85
2338G-46	490	427	63
2338G-47	547	748	-201
2338G-48	930	649	281
2338G-49	400	427	-27
2338G-50	629	662	-33
2338G-51	946	748	198
2338G-52	552	526	26
2338G-53	554	526	28
2338G-56	571	579	-8
2338G-57	792	800	-8
2338G-58	610	511	99
2338G-59	659	511	148
2338G-60	686	579	107
2338G-61	694	649	45
2338G-62	489	511	-22
2338G-65	894	579	315
2338G-66	363	427	-64
2338G-67	636	526	110
2338G-68	636	526	110
2338G-69	628	610	18

ID (Project-Parcel)	Actual Duration	Estimated Duration	Residual (Actual - Estimated)
2338G-70	606	748	-142
2338G-71	642	610	32
2338G-72	642	610	32
2338G-73	642	610	32
2338G-74	483	610	-127
2338G-75	483	610	-127
1431-1	231	339	-108
1431-2	206	339	-133
1431-3-A	206	339	-133
1431-3-B	206	339	-133
1431-3-C	206	339	-133
1431-4	207	339	-132
1431-5	257	339	-82
1431-6	244	339	-95
1431-7	575	561	14
1431-8	188	339	-151
1431-9	297	422	-125
1431-10	558	712	-154
1431-11	575	712	-137
1431-12	544	712	-168
1431-13	544	561	-17
1431-14	446	561	-115
1431-15	447	561	-114
1431-16	472	422	50
1431-17	200	339	-139
1431-19-A	349	422	-73
1431-19-B	349	422	-73
1431-20	497	561	-64

ID (Project-Parcel)	Actual Duration	Estimated Duration	Residual (Actual - Estimated)
1431-20	497	561	-64
1431-21	343	339	4
1431-22	256	422	-166
1431-23	567	561	6
1431-24	567	561	6
1431-25	108	339	-231
1431-26	511	561	-50
1431-27	216	339	-123
1431-28	473	339	134
1431-29	511	561	-50
US79-271	292	197	95
US79-272	180	335	-155
US79-273	89	113	-24
US79-274	152	197	-45
US79-275	207	197	10
US79-276	287	197	90
US79-277	287	197	90
US79-281	148	197	-49
US79-282	148	197	-49
US79-283	172	197	-25
FM535-1	323	379	-56
FM535-2	309	379	-70
619_038-1	437	367	70
619_038-2	481	367	114
619_038-3	437	367	70
619_038-4	466	367	99
619_038-5	448	589	-141
619_038-6	273	367	-94

ID (Project-Parcel)	Actual Duration	Estimated Duration	Residual (Actual - Estimated)
619_037-1	205	376	-171
619_037-2	147	376	-229
619_037-3	156	376	-220
FM812-1	344	379	-35
FM812-2	354	379	-25
FM86CF-1	437	370	67
FM86CF-2	437	370	67
FM86CF-3	375	370	5
FM86CF-4	662	370	292
FM86CF-5	385	370	15
IH35-1	1274	1274	0
IH35-1-Tr	1274	1274	0
IH35-2	1274	1274	0
IH35-2-Tr	1274	1274	0
IH35-3	1274	1274	0
IH35-3-Tr	1274	1274	0
IH35-9	310	347	-37
IH35-10	310	347	-37
IH35-12	357	347	10
IH35-14	574	569	5
IH35-15	1274	1274	0
L230-1	229	379	-150
L230-2	448	601	-153
1431S-1	308	309	-1
1431S-2	263	309	-46
1431S-3	573	531	42
1431S-4	270	309	-39
1431S-5	258	309	-51

ID (Project-Parcel)	Actual Duration	Estimated Duration	Residual (Actual - Estimated)
1431S-6	335	612	-277
1431S-7	253	309	-56
1431S-8	253	309	-56
1431S-9	256	309	-53
1431S-10	256	309	-53
1431S-11	328	309	19
1431S-12	544	531	13
1431S-14	257	309	-52
1431S-15	244	309	-65
1431S-16	257	309	-52
1431S-17	313	309	4
1431S-18	733	531	202
1431S-19	733	531	202
1431S-20	733	531	202
1431S-21	315	309	6
1431S-22	221	309	-88
1431S-23	263	309	-46
1431S-24	263	309	-46
1431S-25	253	309	-56
1431S-26	258	309	-51
RM2341-1	617	352	265
RM2341-2	772	656	116
RM2341-3	638	656	-18
RM2341-4	227	352	-125
RM2341-5	606	352	254
RM2341-6	841	656	185
RM2341-7	772	656	116
RM2341-8	434	352	82

ID (Project-Parcel)	Actual Duration	Estimated Duration	Residual (Actual - Estimated)
RM2341-9	592	656	-64
RM2341-10	596	352	244
RM2341-11	597	656	-59

Appendix 14. ANOVA of Total Duration and Sub-Durations by Qualitative Inherent Factors

	Total	Sub 1	Sub 2
Transitional Area	F(2, 166)=26.8 P<.001	F(2, 160)=3.8 p=.024	
	Urban ≠ Rural Urban ≠ Suburban	Urban ≠ Suburban	
Acquisition Method	F(2, 166)=8.1 P<.001		
	Deed ≠ ED		
Owership Type	F(2, 166)=6.4 p=.002		F(2, 160)=6.5 p=.002
	Business ≠ Multiple		Business ≠ Multiple
Use of Property			
Improvements			
Bisection of Property			F(1, 161)=6.7 p=.010
Improvements Affected NOT in Acquired Area			F(1, 161)=12.4 p=.001
Title Issue	F(1, 167)=7.7 p=.006		F(1, 161)=5.3 p=.023
Mapping/ Survey Issue	F(1, 167)=12.3 p=.001	F(1, 161)=9.3 p=.003	F(1, 161)=6.9 p=.009
Exchange	F(1, 167)=78.5 p<.001		
Relocation			F(1, 161)=6.6 p=.011
Demolition			

	Sub 3	Sub 4a	Sub 5a
Transitional Area	F(2, 160)=5.4 p=.006 Urban ≠ Rural Urban ≠ Suburban	F(2, 131)=21.8 P<.001 Urban ≠ Rural Urban ≠ Suburban	F(2, 124)=6.5 p=.002 Urban ≠ Rural Urban ≠ Suburban
Acquisition Method		F(1, 132)=10.1 p=.002 Deed ≠ ED then Deed	F(1, 125)=5.6 p=.019 Deed ≠ ED then Deed
Owership Type		F(2, 131)=9.1 P<.001 Business ≠ Multiple	
Use of Property			
Improvements			
Bisection of Property			
Improvements Affected NOT in Acquired Area			
Title Issue			F(1, 125)=15.6 p<.001
Mapping/ Survey Issue		F(1, 132)=5.8 p=.017	
Exchange	F(1, 161)=11.4 p=.001	F(1, 132)=62.7 p<.001	F(1, 125)=10.9 p=.001
Relocation			
Demolition			

	Sub 4b	Sub 5b	Sub 6	Sub 7
Transitional Area			F(2, 58)=8.3 p=.001	F(2, 43)=6.1 p=.005
			Rural ≠ Suburban	Rural ≠ Suburban
Acquisition Method				
Owership Type				
Use of Property				
Improvements				
Bisection of Property				
Improvements Affected NOT in Acquired Area				
Title Issue		F(1, 48)=13.6 p=.001		
Mapping/ Survey Issue				
Exchange				
Relocation				
Demolition				

	Sub 8	Sub 9	Sub 10	Sub 11
Transitional Area	F(2, 35)=13.4 P<.001 Rural ≠ Suburban			F(1, 100)=13.1 P<.001 Rural ≠ Suburban
Acquisition Method				F(2, 99)=3.7 p=.029 Deed ≠ ED
Owership Type			F(2, 29)=4.4 p=.021 Business ≠ Individual	
Use of Property				
Improvements				
Bisection of Property				
Improvements Affected NOT in Acquired Area				
Title Issue				
Mapping/ Survey Issue				
Exchange				
Relocation				
Demolition				

Appendix 15. Correlations between Quantitative Inherent Factors and Total Duration and Sub-Durations

	Number of Parcels	Size	Percentage Taken
Total	r=.156*, n=169, p=0.042		
Sub 1	r=.230**, n=163, p=0.003		
Sub 2	r=.219**, n=163, p=0.005	r=.186*, n=163, p=0.018	
Sub 3			
Sub 4a			
Sub 5a			
Sub 4b			
Sub 5b		r=.347*, n=50, p=0.014	
Sub 6			
Sub 7			
Sub 8			
Sub 9			
Sub 10			
Sub 11			r=-.228*, n=102, p=0.021

Appendix 16. Correlations among Total Duration and Sub-Durations

	Total	Sub 1	Sub 2	Sub 3
Total	n=169			
Sub 1		n=163		
Sub 2	r=.189*, n=161, p=0.016		n=163	
Sub 3	r=.245**, n=161, p=0.002			n=163
Sub 4a	r=.821**, n=133, p<0.001			
Sub 5a	r=.478**, n=127, p<0.001	r=-.188*, n=121, p=0.038		
Sub 4b	r=.246*, n=80, p=0.028	r=-.237*, n=76, p=0.039		
Sub 5b	r=.324*, n=49, p=0.023			
Sub 6				
Sub 7	r=.556**, n=44, p<0.001			
Sub 8	r=.535**, n=37, p=0.001			
Sub 9				r=.570**, n=28, p=0.002
Sub 10	r=.527**, n=32, p=0.002			
Sub 11				

	Sub 4a	Sub 5a	Sub 4b	Sub 5b	Sub 6
Total					
Sub 1					
Sub 2					
Sub 3					
Sub 4a	n=134				
Sub 5a		n=127			
Sub 4b	r=.526**, n=49, p<0.001		n=82		
Sub 5b	r=.511*, n=23, p=0.013			n=50	
Sub 6				r=.363*, n=44, p=0.016	n=61
Sub 7	r=.883**, n=11, p<0.001				
Sub 8	r=-.999**, n=4, p=0.001	r=.999**, n=4, p=0.001			
Sub 9					
Sub 10					
Sub 11		r=.245*, n=78, p=0.030			

	Sub 7	Sub 8	Sub 9	Sub 10	Sub 11
Total					
Sub 1					
Sub 2					
Sub 3					
Sub 4a					
Sub 5a					
Sub 4b					
Sub 5b					
Sub 6					
Sub 7	n=46				
Sub 8		n=38			
Sub 9			n=32		
Sub 10				n=32	
Sub 11		r=.557*, n=18, p=0.016			n=102

Appendix 17. Example of a "Summary Sheet" for a R/W Acquisition Sub-Period

SUMMARY SHEET FOR SUB-DURATION 1

From:	**R/W Release**
To:	**Appraisal Ordered**

<u>Descriptive Statistics (days):</u>

Minimum:	2	*Expert Opinion:*	8
Average:	61.4	*Standard Deviation:*	54.4
Maximum:	442		

Confidence Level:	50%	70%	90%
Expectedly Up to:	98	118	151

<u>Risky Issues:</u>

<u>Important *Factors* and Durations:</u>

Transitional area
Mapping/survey issues
Number of parcels in project
Sub-duration 5a (Accepted *to* Closing)
Sub-duration 4b (Offered *to* Approval of Final Offer)
Sub-duration 6 (Condemnation Start *to* Minute Order)

Appendix 18. Summary of Assessment Results of Tested Projects Using the APRA

Factor	Level	Score
Max	3.8	19.5
Min	1.1	1.5
Average	**2.3**	6.5
St. Dev.	0.62	3.1
95th percentile	3.36	12.2
75th percentile	2.75	8.1
50th percentile	2.21	5.9
25th percentile	1.82	4.6
5th percentile	1.41	2.8
Average for R/W and Utilities elements	2.6	8.6

Section and Category	Level	Score
SECTION I	**1.9**	**6.5**
A. PROJECT STRATEGY	1.8	6.4
B. OWNER/OPERATOR PHILOSOPHIES	2.0	5.7
C. PROJECT REQUIREMENTS	2.0	7.5
SECTION II	**2.4**	**6.1**
D. SITE INFORMATION	2.3	6.4
E. LOCATION & GEOMETRY	1.9	5.6
F. STRUCTURES	2.3	6.3
G. DESIGN PARAMETERS	2.9	7.5
H. INSTALLED EQUIPMENT	2.6	4.7
SECTION III	**2.9**	**6.3**
I. ACQUISITION STRATEGY	2.7	7.6
J. DELIVERABLES	3.6	3.6
K. PROJECT CONTROL	2.7	8.2
L. PROJECT EXECUTION PLAN	2.5	5.7

Appendix 18. Summary of Assessment Results of Tested Projects Using the APRA (Continued)

#	Element	Level	Score
1	A1. Need & Purpose Documentation	1.3	2.7
2	A2. Investment Studies & Alternatives Assessments	1.7	6.3
3	A3. Programming & Funding Data	2.6	13.0
4	A4. Key Team Member Coordination	2.1	6.4
5	A5. Public Involvement	1.3	3.7
6	B1. Future Expansion & Alteration Considerations 1	1.9	6.3
7	B2. Operating Philosophy	2.2	6.1
8	B3. Maintenance Philosophy	2.2	5.7
9	B4. Future Expansion & Alteration Considerations	1.6	4.6
10	C1. Functional Classification & Use	1.1	1.5
11	C2. Evaluation of Compliance Requirements	1.5	3.7
12	C3. Survey of Existing Environmental Conditions	2.1	8.7
13	C4. Determination of Utility Impacts	3.5	19.5
14	C5. Value Engineering	1.8	3.9
15	D1. Geotechnical Characteristics	2.6	7.4
16	D2. Hydrological Characteristics	2.6	8.1
17	D3. Surveys & Planimetrics	1.9	4.6
18	D4. Permitting Requirements	1.8	4.4
19	D5. Environmental Documentation	1.8	5.9
20	D6. Property Descriptions	2.2	5.4
21	D7. Ownership Determinations	2.3	4.9
22	D8. Right-of-Way Mapping	2.9	8.1
23	D9. Constraints Mapping	2.0	5.8
24	D10. Right-of-Way Site Issues	2.7	9.1
25	E1. Horizontal & Vertical Alignment	1.8	4.9
26	E2. Control of Access	1.7	4.5
27	E3. Schematic Layouts	1.9	7.0
28	E4. Cross-Sectional Elements	2.2	6.2
29	F1. Bridge Structure Elements	2.1	5.4
30	F2. Hydraulic Structures	2.4	7.1
31	F3. Miscellaneous Design Elements	2.4	5.8
32	G1. Provisional Maintenance Requirements	2.9	6.1
33	G2. Constructability	2.8	8.9
34	H1. Equipment List	2.1	3.4
35	H2. Equipment Location Drawings	3.2	5.1

Appendix 18. Summary of Assessment Results of Tested Projects Using the APRA (Continued)

#	Element	Level	Score
36	H3. Equipment Utility Requirements	2.4	5.6
37	I1. Long-Lead Parcel & Utility Adjustment Identification	3.1	14.1
38	I2. Long-Lead/Critical Equipment & Materials Identification	2.8	6.2
39	I3. Local Public Agencies Utilities Contracts & Agreements	2.5	8.2
40	I4. Utility Agreement & Joint-Use Contracts	3.2	11.6
41	I5. Project Delivery Method & Contracting Strategies	1.7	3.1
42	I6. Design/Construction Plan & Approach	3.4	9.0
43	I7. Procurement Procedures & Plans	3.8	7.5
44	I8. Appraisal Requirements	2.4	5.6
45	I9. Advance Acquisition Requirements	1.6	3.1
46	J1. CADD/Model Requirements	1.4	2.1
47	J2. Documentation/Deliverables	2.1	4.4
48	K1. Right-of-Way & Utilities Cost Estimates	2.6	9.7
49	K2. Design & Construction Cost Estimate	3.1	12.1
50	K3. Project Cost Control	2.8	8.1
51	K4. Project Schedule Control	3.4	10.0
52	K5. Project Quality Assurance & Control	2.4	4.4
53	K6. Safety Procedures	2.2	4.6
54	L1. Environmental Commitments & Mitigation	2.2	5.4
55	L2. Interagency Coordination	1.5	2.9
56	L3. Local Public Agency Contractual Agreements	1.9	4.8
57	L4. Interagency Joint-Use Agreements	2.6	6.4
58	L5. Preliminary Traffic Control Plan	3.4	8.1
59	L6. Substantial Completion Requirements	3.1	6.8

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VITA

Tiendung Le was born in Phu Tho, Vietnam to Le Xuan Ty and Nguyen Thi Thanh Binh. He attended elementary, middle, and high schools in Phu Tho before moving to Hanoi in 1995 for higher education. Le studied civil engineering at the University of Civil Engineering and business administration at the National Economics University in Hanoi. He graduated from these universities in 2000 and 2001, respectively. He worked in the industry for 1.5 years before continuing with graduate studies in construction engineering and project management. He obtained a Master's degree in Construction Engineering and Management from the Asian Institute of Technology in Thailand in 2004 and a Master's degree in Project Management from the University of Technology, Sydney in 2005. In summer 2005, he was awarded a Vietnam Education Foundation fellowship by the U.S. government for his doctoral study at the University of Texas at Austin (UT). During his doctoral study, Le conducted research in the area of front end planning for transportation infrastructure projects under the supervision of Carlos H. Caldas and G. Edward Gibson, Jr. He was a teaching assistant in ten classes at both Cockrell School of Engineering and Red McCombs School of Business. Le is highly active in extracurricular activities. He served as the Vice President of the Vietnam Education Foundation Fellows and Scholars Association from December 2006 to January 2008. He is the President of the CEPM program's Graduate Student Organization at UT as of summer 2009.

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